PHILIPS

Operating manual

Dual-trace oscilloscope PM 3250(X)

9499 440 11511

730416/1/04

IMPORTANT

In correspondence concerning this apparatus, please quote the type number and serial number as given on the type plate at the rear of the apparatus.

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I. Introduction

General information

The 04 version of the PM 3250 oscilloscope has been designed for general laboratory applications and features a dual channel d.c. to 50 MHz vertical deflection system, with a maximum sensitivity of 2 mV/div. This sensitivity may be increased to 200 μV/div. at a bandwidth of 5 MHz. The drift which is inherent at these high sensitivities is extensively reduced by a feed-back system.
There are field effect transistors incorporated in the input stages, and power output sockets enable active measuring probes and other devices to be supplied.
During differential measurements, it is possible to display the differential signal and the channel B signal simultaneously. A signal delay line has been incorporated so that the leading edges of extremely fast signals may be displayed.
The PM 3250 is equipped with a main time-base and a delayed time-base, each of which contains a complete trigger unit. The delayed time-base enables detailed displays of complex signals to be made across the entire width of the screen. There is a single sweep facility incorporated in the main time-base circuit. The maximum horizontal deflection speed using the x5 magnifier is 10 ns/div.
This oscilloscope is capable of providing an extremely high level of display intensity, especially useful for writing very fast single shot or low repetition rate signals.

PM 3250X

The PM 3250X is a special television and telecommunication oscilloscope.
Unlike the basic PM 3250, the PM 3250X is equipped with sync. separator, x10 magnifier and mains triggering circuits. The PM 3250X is also equipped with an additional horizontal preamplifier (instead of the former EXT via Y_B amplifier) and gating stage which enables external signals (connected to the oscilloscope via the main time-base TRIGG./EXT.X socket) to be used to drive the horizontal output amplifier.
Both LEVEL x5 trigger selectors of the basic PM 3250, are deleted in favor of the TV field and line sync. switches.

II. Specification

Properties expressed in numerical values with stated tolerances are guaranteed for nominal mains voltages. Numerical values without tolerances merely serve as a guide and represent the characteristics of an average instrument.

VERTICAL AMPLIFIERS

two identical amplifiers (channels A and B) drift-compensated, d.c.-coupled

Display modes

signal A only
signal B or −B only
signal A and +B or −B chopped
signal A and +B or −B alternate
signal (A−B) only
signal (A−B) and +B or −B chopped
signal (A−B) and +B or −B alternate

Chopper frequency

1 MHz (in gain x10 mode: 200 kHz)

Bandwidth

Gain x1 mode
DC : 0 Hz to 50 MHz (−3 dB)
AC : 1,5 Hz to 50 MHz (−3 dB)
Rise-time ⩽ 7 ns

Gain x10 mode
DC : 0 Hz to 5 MHz (−3 dB)
AC : 1,5 Hz to 5 MHz (−3 dB)
Rise-time ⩽ 70 ns

Deflection factor

2 mV/div. to 20 V/div. in 13 calibrated steps (1, 2, 5 sequence) in gain x1 mode
Uncalibrated continuous control (1: > 2,5) between steps
200 μV/div. in 2 mV/div. attenuator position and gain x10 mode

Accuracy

±3 % with respect to the 20 mV/div. attenuator position in gain x1 mode
Additionally 2 % in gain x10 mode
At max. brightness 3 % more tolerance

Input impedance

1 MΩ//20 pF

Input RC time

100 ms

Maximum input voltage

DC : ±400 V
AC : 400 V_{p-p} permissible for 30 sec. only
200 V_{p-p} continuously

Positioning range

Gain x1 mode
3 times useful screen height (24 div.)

Gain x10 mode
20 times useful screen height (160 div.)

Signal delay

Visible, 30 ns; total delay line 65 ns

Overshoot/undershoot of signal display

A and B : ⩽ 2 %
(A−B) and −B: ⩽ 5 %

Cross-talk

Simultaneous display decoupling factor (see IEC 351) at 30 MHz, 2 mV/div. and 6 divisions disturbing voltage: Typically 25

Common-mode rejection factor

common mode voltage 800 mV at 20 mV/div.

Gain x1 mode

50 Hz ⩾ 400	}	maximum permissible common-mode voltage 5x screen height
100 Hz 400		
5 MHz 40		
20 MHz ⩾ 20		

Gain x10 mode

50 Hz ⩾ 400	}	maximum permissible common-mode voltage 50x screen height
2 kHz 400		
1 MHz 100		

Maximum drift at maximum amplification

Typical values at 200 μV/div. after the instrument has been operating for half an hour under ambient room conditions:

Short-term measured over 1 min period	0,3 div.
Long-term measured over 1 hr period	0,5 div.
Long-term measured over 1 week	1,0 div.
Influence of temperature	0,2 div./°C

Dynamic range for sine-wave signals

Continuous control in position CAL

100 kHz ⩾ 40 div.	}	x1 mode
15 MHz ⩾ 25 div.		
50 MHz ⩾ 6 div.		
100 kHz ⩾ 400 div.	}	x10 mode
5 MHz ⩾ 170 div.		

Displayed noise, tangentially measured, including periodic deviations (P.A.R.D.)

Source resistance 50 ohm

at 2 mV/div.	⩽ 0,1 div.
at 200 μV/div.	⩽ 0,5 div.

Source resistance 10 megohm

at 2 mV/div.	⩽ 0,2 div.
at 200 μV/div.	⩽ 0,5 div.

TRIGGERING

Source

Internal channel A (or A−B), internal channel B or external

Slope

Positive or negative

Trigger coupling

LF	3 Hz (−3 dB)	-	1 MHz (−3 dB)
HF	2 kHz (−3 dB)	-	> 75 MHz
DC	0 Hz	-	> 75 MHz

Trigger sensitivity

Internal : ⩽ 0,5 div. up to 20 MHz
⩽ 1,0 div. up to 50 MHz

External: ⩽ 0,5 V up to 20 MHz
⩽ 1,0 V up to 50 MHz

Input impedance

1 megohm//20 pF. Same for the vertical channels so probe can be used both for measuring and triggering

Maximum input voltage

DC : ±400 V
AC : 400 V_{p-p}

Level range

Internal :	position x1	8 div. approx.
	position x5	40 div. approx.
External:	position x1	6 V approx.
	position x5	30 V approx.

MAIN TIME-BASE

Sweep rates	50 ns/div. to 1 s/div. in 23 calibrated steps (1, 2, 5 sequence): uncalibrated vernier allows continuous control (1: ⩾ 2,5) between the steps. x5 magnifier extends fastest sweep rate to 10 ns/div.
Accuracy	±3 % measured over the middle eight div. for all ranges except 1 s/div., 0,5 s/div. and 0,2 s/div., which have a tolerance of ±5 %. In the x5 position there is an additional tolerance of ±2 %.
Positioning range	At x5 magnification the ends of the trace can be brought on to the screen by the X POSITION control
Modes	Triggered, automatic, single sweep

DELAYED TIME-BASE

Sweep rates	50 ns/div. to 0,5 s/div. in 22 calibrated steps (1, 2, 5 sequence); uncalibrated vernier allows continuous control (1: ⩾ 2,5) between the steps. x5 magnifier extends fastest sweep rate to 10 ns/div.
Accuracy	±3 % measured over the middle eight div. for all ranges except 0,5 s/div., and 0,2 s/div., which have a tolerance of ±5 %. At x5 magnification there is an additional tolerance of ±2 %.
Positioning range	At x5 magnification the ends of the trace can be brought on to the screen by the X POSITION control
Delay control	Incremental multiplier linearity typically 0,3 % measured at 1 ms/div. by main time-base. Delay-time jitter < 1: 20000 Initial delay time, typically 30 ns
Modes	Position STARTS: triggered by main sweep immediately after delay time Position TRIGG : triggered by measuring signal after time (applicable for jitter-free measurements). Position OFF : delayed time-base is switched off.

HORIZONTAL AMPLIFIER

X-deflection via Y_B input (Gain x10 mode, beam finder and x5 magnification inoperative for the X channel)

Bandwidth	DC : 0 Hz to 5 MHz, (−3 dB) AC : 1,5 Hz to 5 MHz, (−3 dB)
Deflection coefficient Input impedance Input RC-time Maximum input voltage	Refer to 'Vertical Amplifiers'
Dynamic range	1 kHz: 8 div. 5 MHz: −3 dB
Overshoot	5 % with a rise-time of 100 ns
Phase shift between X and Y amplifiers	⩽ 3° at 100 kHz
Polarity	positive or negative

SWEEP MAGNIFIER

Magnification	x5 the X-amplifier gain
Accuracy	2 % tolerance added to specified sweep accuracy

Fastest sweep rate	10 ns/div.

MAIN TIME-BASE OUTPUT — Not protected against external voltages.

Sawtooth voltage	(Open-circuit) +8 V, base line 0 V
Output resistance	4,7 kΩ

DELAYED GATE OUTPUT — Not protected against external voltages.

Square-wave gate voltage	(Open-circuit) +2 V, base line 0 V. Signal available only in position DEL'D TB of X DEFL. switch.
Output resistance	600 Ω

CALIBRATION — Not protected against external voltages

Calibration voltage	600 mV_{p-p} ±1 %
Calibration current	6 mA_{p-p} ±2 % (short-circuit)
Frequency	2 kHz ±1 %

Z MODULATION

Source	Internal or external.
Internal:	Brightness controlled by main time-base Brightness controlled by main time-base intensified by delayed time-base Brightness controlled by delayed time-base in CHOPP position the beam is suppressed during switching
External:	Via an a.c. or d.c.-coupled input
Voltage for visible indication	5 V
Polarity	a.c.-coupled: negative to increase trace intensity d.c.-coupled: positive to increase trace intensity
Bandwidth	DC : 0 Hz to 5 MHz AC : 3 kHz to 50 MHz
Input impedance	DC : 1 MΩ//20 pF AC : 50 Ω

DISPLAY

Cathode ray tube	D14 – 160 GH/09, internal graticule with dotted calibration lines at 10 % and 90 %.

Useful screen area	8 cm x 10 cm
Phosphor	GH (P31)
Total acceleration voltage	10 kV

Graticule illumination	Continuously adjustable
Beamfinder	Push-button control for reducing the deflection sensitivity to display the signal within the screen area. Also resets the X magnifier to x1 position if in the x5 position.

POWER SUPPLY

Mains voltages

Nominal Voltage	Permissible Voltage Range*	Fuse**
110 V	100 V to 120 V	2 A 'slow blow'
125 V	117 V to 140 V	
SPEC (145 V)	133 V to 160 V	
200 V	184 V to 220 V	1 A 'slow blow'
220 V	200 V to 240 V	
245 V	217 V to 260 V	

Power consumption: 100 W approximately

Mains frequency: 46 Hz to 440 Hz

Accessory power supply: +24 V d.c. and −24 V d.c. suitable for supplying Philips active accessories, e.g., PM 9347, PM 9352, PM 9353.

TEMPERATURE RANGE

Operating within specification: 0 °C to +45 °C

Operating range: −10 °C to +55 °C

Storage range: −40 °C to +70 °C

(These temperature ranges comply with IEC Standard 68)

PHYSICAL

Overall Dimensions

Height	24,5 cm
Width	34,0 cm
Depth	53,5 cm

Weight: 18,5 kg (40 lb) approximately

PM 3250X

SYNC. SEPARATOR

Triggering: Triggering is possible on all TV signals greater than 0,5 div. but less than 16 div. amplitude

MAINS TRIGGERING

Signal source: Mains frequency derived from a winding of the supply transformer

EXTERNAL HORIZONTAL INPUT

Horizontal bandwidth: 5 Hz to > 500 kHz

Input impedance: 1 MΩ//20 pF

Phase: A positive-going input voltage causes the spot to move from left to right across the screen.

Input connector: The TRIGG./EXT. X connector, provided that the MAIN TB/DEL'D TB/EXTERN switch is set to its EXTERN position.

Input sensitivity: 1 V/div. (or 0.1 V/div. when the X MAGN. switch is set to x10)

* Measured at 50 Hz and with a distortion that reduces the peak voltage by less than 5 %.

** Located at rear side of the cabinet.

Adjustable attenuation	A preset potentiometer, accessible through a hole in the right hand side cover of the oscilloscope, providing an adjustable attenuation of approximately x5. Fully clock-wise is the calibrated position (x1).

SWEEP MAGNIFIER

Magnification	x10. (the magnification is x5 in the basic version of the oscilloscope).
Accuracy at x10 magnification	As stated in the basic PM 3250 specification, up to 10 ns/div.

III. Accessories

The oscilloscope is supplied complete with the following accessories:

- A manual
- Two adaptors, BNC to 4 mm (PM 9051)
- Trimming rod
- Contrast filter green (installed)
- Contrast filter grey
- Collapsible viewing hood (PM 9366)

The following items are also available as optional accessories:

– Current loop	PM 9040
– HF 1:1 probe	PM 9335
– HF 10:1 probe	PM 9350
– TV probe	PM 9347 (not necessary for PM 3250X)
– Miniature probe	PM 9352
– FET probe	PM 9353
– 100:1 2 kV probe	PM 9358
– Adaptor for rack mount	PM 9364
– Polaroid oscilloscope camera set	PM 9380
– Supplementary lens for PM 9380	PM 9373
– Adaptor for PM 9380	PM 9376
– Carrying case	PM 9394
– Trolley	PM 9395

IV. Description of the block diagram

A. GENERAL

The oscilloscope PM 3250 consists of the following parts:
- a dual channel vertical system
- Main time-base
- Delayed time-base
- a horizontal amplifier
- an unblanking circuit
- a cathode ray tube circuit
- a stabilised power supply
- a calibration voltage generator

B. DUAL CHANNEL VERTICAL SYSTEM

This dual channel vertical system contains the following components:
- An "AC/O/DC" switch by means of which the coupling of the input signal can be selected.
- A step attenuator controlled by switch "AMPL" enables the adjustment of the vertical deflection sensitivity in calibrated steps.
- A FET source follower giving the circuit a high input impedance
- A pre-amplifier
- An emitter follower adapting the pre-amplifier to the next stage.
  By means of potentiometer "AMPL", the vertical deflection sensitivity can be continuously controlled.
  From the emitter follower the signal is distributed to:
  - the intermediate amplifier
  - the trigger pick-off stage
  - the drift reduction circuit
- A drift reduction circuit which senses the input voltage and a part of the output voltage of the pre-amplifier to determine the drift voltage originated in the pre-amplifier. After amplification, this drift voltage is fed back to the second input of the pre-amplifier. In this way the overall drift is strongly reduced.
- An amplifier which further amplifies the signal. By means of the "Y POSITION" control the trace can be shifted in vertical direction. When switch "A/OFF/A–B" is in position "A–B", the signal of channel B is also applied to the amplifier of channel A so that the difference between the signals of channel A and B will be displayed.
- An electronic switch which either blocks or passes the signal, depending on the position of the multivibrator.
- Channel B has been provided with a signal polarity invertor, operated with switch "B/OFF/–B".
- A driver stage for the electronic switches, consisting of a bistable multivibrator and a blocking oscillator.
  In position "CHOPP" of switch "CHOPP/ALT" the blocking oscillator works at a fixed frequency and the electronic switches are successively opened and closed so that successively part of the signal of channel A and part of the signal of channel B are displayed.
  In position "ALT" the blocking oscillator is not oscillating and is driven by the flyback signals from the main time-base generator, so that alternately the complete signals of channel A and channel B are displayed.
  In position "OFF" of switch "A/OFF/A–B" the signal of channel A is blocked by the electronic switch.
  In position "OFF" of switch "B/OFF/–B" the signal of channel B is blocked.
  When switch "X DEFL" is in position "EXT via Y_B", the signal of channel B is applied to the horizontal output amplifier via the electronic switch and a gate circuit.

  After the electronic switches, the circuits are common to both vertical channels.
  These circuits are:
- An amplifier stage which contains two switches:
  - the "GAIN" switch by means of which the deflection sensitivity of both channels can be increased by a factor 10;

- the "BEAMFINDER" switch by means of which the deflection sensitivity can be reduced to such an extent that the signal is always displayed within the screen.

– A delay-line driver stage.
– A delay-line that delays the vertical signals to such an extent that the steep leading edges of fast signals are still displayed.
– An output amplifier which feeds the signals to the vertical deflection plates.

C. TIME-BASES

The main and delayed time-bases contain the following circuits:
– A common trigger pick-off stage that amplifies the signals coming from the vertical channels A and B, and deliver them to the trigger units. In position "A–B" of switch "A/OFF/A–B", it supplies the signal A–B instead of signal A.
– A "Y_A/Y_B/EXT" switch by means of which the trigger signal source can be selected.
– A "LF/HF/DC" switch by means of which the input frequency range of the trigger circuit can be selected.
– An amplifier stage which contains:

- a "LEVEL" potentiometer by means of which the trigger level can be varied. In the pull position, the range of the "LEVEL" potentiometer increases 5 times.
- a "+/–" switch by means of which the polarity of the trigger signal can be inverted enabling triggering on the positive as well as on the negative slope of the input signals.

– A pulse shaper and a differentiator that supply well-defined trigger pulses for switching the sweep gating multivibrator (and in position "AUTO" of switch "SINGLE/TRIGG/AUTO" for driving the automatic circuit in the main time-base generator).
– A sweep gating multivibrator which starts and stops the integrator.
– An integrator which delivers the sawtooth signal required for the horizontal deflection.
This integrator comprises the charging capacitors and resistors selected by the "TIME/div." switch in order to adjust the time coefficients in calibrated steps.
Continuous control of the time coefficients is effected by means of the "TIME/div." potentiometer.
– A hold-off circuit which switches back the sweep gating multivibrator and blocks its input during the flyback of the sawtooth signal.

The main time-base generator contains also:
– An automatic free-run circuit or auto-circuit, which makes the main time-base generator free-running when there are no trigger pulses. (The auto-circuit only works in position "AUTO" of switch "SINGLE/TRIGG/AUTO").
– A single sweep circuit which causes the main time-base generator to deliver only one sawtooth pulse, after the "SET READY" knob has been pressed and upon receipt of the trigger pulse. (This circuit only works in position "SINGLE" of switch "SINGLE/TRIGG/AUTO").

The delayed time-base generator contains also:
– A "DELAY TIME MULTIPLIER" control, a comparator and a reset multivibrator which determine the delay time for the delayed time-base generator.
– An "AFTER DELAY TIME" switch by means of which two working modes of the delayed time-base generator can be selected, viz.:

- position "STARTS": The delayed time-base generator starts immediately after the delay time.
- position "TRIGG": The delayed time-base triggered – after the delay time – by the pulses coming from its trigger unit.

– When the "X DEFL" switch is in the position "MAIN TB", that part of the trace coinciding with the delayed sweep is intensified, except in the "OFF" position of the delayed "TIME/div." switch.

D. HORIZONTAL AMPLIFIER

This amplifier serves for amplifying one of the internal sawtooth voltages or the signal of vertical channel B (depending on the position of the switch "X DEFL"), before this is applied to the horizontal deflection plates.

This circuit contains also:
– A "X POSITION" control by means of which the trace can be shifted in horizontal direction (not operating in position "EXTERN via Y_B")

– A "X MAGN" control by means of which the horizontal amplification can be increased by a factor 5 (not operating in position "EXTERN via Y_B")
– A "BEAMFINDER" switch by means of which the deflection sensitivity can be reduced to such an extent that the signal is always displayed within the screen.

E. OTHER UNITS

The PM 3250 contains also the following units:

- An unblanking circuit with a DC and an AC input.
- A cathode-ray tube circuit with an "INTENSITY" and a "FOCUS" control.
- A stabilised power supply which delivers the supply voltages both for the circuits and for the cathode-ray tube.
- A calibration unit.

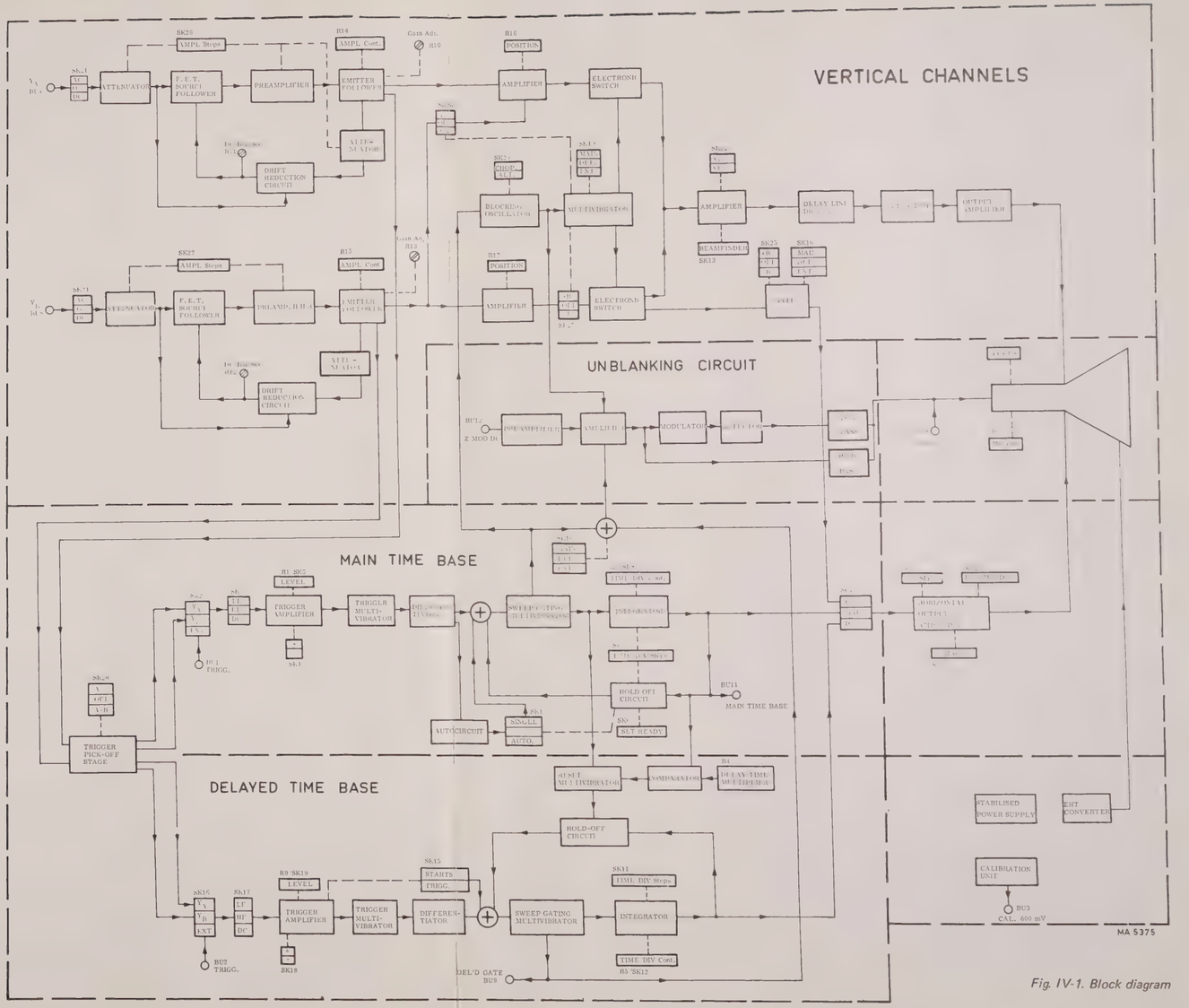

Fig. IV-1. Block diagram

V. Installation

A. MAINS ADJUSTMENT AND FUSES

Before connecting the oscilloscope to the supply, set its voltage adaptor to suit the local mains voltage.
The voltage adaptor, which is located on the rear panel of the oscilloscope, provides means by which nominal mains voltages of 110 V, 125 V, 145 V (SPEC), 200 V, and 240 V may be selected. The voltage to which the adaptor has been set is shown through a hole in the cover plate.
The fuse holder which is mounted on the rear panel normally carries a 1 A fuse, but a 2 A should be fitted if the oscilloscope is to be connected to a mains voltage of less than 200 V (see chapter II).
Check that the fuse is of the specified type and current rating before connecting the oscilloscope to the mains.
The use of repaired fuses and the short-circuiting of fuse holders is prohibited.

B. EARTHING

In the interests of safety, the oscilloscope must be connected to earth via either the front or rear earthing terminal (identified by the symbol ⏚) or via the mains lead, provided that the supply socket is equipped with an earth connection. Care must be taken that the earth line to the oscilloscope is not interrupted due to the use of an extension lead or device which is not fitted with an earth conductor.
Double earthing must be avoided because this gives rise to hum.

C. SWITCHING ON

Ensure that the oscilloscope is set to the nominal value of the mains supply before it is switched on.
The POWER ON switch is located, together with an associated indicator lamp, on the front panel immediately beneath the screen bezel.
The oscilloscope must never be switched on whilst any circuit board has been removed.
Never remove a printed wiring board until at least one minute after the oscilloscope has been switched off.

Fig. V-1. Rear view

VI. Knobs, sockets and their functions

MAIN TIME-BASE

AUTO/TRIGG/SINGLE	Mode switch with three positions: AUTO : the main time-base is free running in absence of trigger signals TRIGG : the time-base is normally triggered. SINGLE: the time-base runs only once.
Y_A/Y_B/EXT	Choice of the trigger source: Y_A : Triggering on the signal fed to channel A or on the differential signal in position A–B of switch A/OFF/A–B. Y_B : Triggering on the signal fed to channel B. EXT: Triggering on a signal connected to socket TRIGG.
LF/HF/DC	Choice of the trigger coupling: LF: via a band-pass filter for frequencies between 3 Hz and 1 MHz HF: via a high-pass filter for frequencies higher than 2 kHz DC: triggering signals are direct-coupled.
+/–	Choice of triggering on the positive- or negative-going edge of the triggering signal.
LEVEL	Adjusting the triggering level.
PULL FOR x5	The level range can be increased 5x by means of this pull-push switch.
SET READY	If switch AUTO/TRIGG/SINGLE is in the SINGLE position, the time-base runs once after pressing the SET READY button upon receipt of a trigger pulse.
TIME/div. or DELAY TIME	Control in steps of the time coefficient of the main time-base.
TIME/div. -CAL (red)	Continuous control of the time coefficient of the main time-base. In the position CAL, the time coefficient is calibrated.
TRIGG 1 MΩ//20 pF	BNC input socket for external triggering.

HORIZONTAL AMPLIFIER

X POSITION	Horizontal positioning of the display, except in pos. EXTERN via Y_B of switch X DEFL.
X MAGN PULL FOR x5 (red)	5x increase of the horizontal deflection coefficients by means of a pull-push switch.
MAGN. ON	Pilot lamp which lights up when the X MAGN switch is in the x5 position.
X DEFL	Selector switch with three positions: MAIN TB : The horizontal deflection voltage is supplied by the main time-base. A part of the trace is (except in position OFF of the delayed TIME/div. switch) intensified. DEL'D TB : The horizontal deflection voltage is supplied by the delayed time-base. EXTERN via Y_B: The horizontal deflection voltage is supplied by an external source via the vertical B channel.

DELAYED TIME-BASE

DELAY TIME MULTIPLIER
Control of the delay time in combination with the TIME/div. controls of the main time-base.

AFTER DELAY TIME
Choice of the start point of the delayed time-base after the delay time:
STARTS: The delayed time-base is started immediately after the delay time.
TRIGG : The delayed time-base is started, after the delay time, only when a trigger pulse is received.

Y_A/Y_B/EXT
Choice of the trigger source:
Y_A : Triggering on the signal fed to channel A or on the differential signal in position A–B of switch A/OFF/A–B.
Y_B : Triggering on the signal fed to channel B.
EXT : Triggering on signal connected to socket TRIGG.

LF/HF/DC
Choice of the trigger coupling:
LF : via a band-pass filter for frequencies between 3 Hz and 1 MHz.
HF : via a high-pass filter for frequencies higher than 2 kHz.
DC : triggering signals are coupled directly.

TIME/div.
Control in steps of the time coefficients of the delayed time-base.
In the position OFF the delayed time-base is switched off.

TIME/div. -CAL (red)
Continuous control of the time coefficients of the delayed time-base.
In the position CAL, the time coefficient is calibrated.

TRIGG

1 MΩ//20 pF
BNC input socket for external trigger voltage.

+/–
Choice of triggering on the positive- or negative-going edge of the trigger signal.

LEVEL
Adjustment of the trigger level.

PULL FOR x5
By means of this pull-push switch, the LEVEL range can be increased 5x.

VERTICAL CHANNELS

GAIN
Selector switch with two positions:

x1-x10
x1 : The vertical deflection coefficients have the values as indicated on the front panel.
x10: The vertical deflection coefficients indicated on the front panel are reduced by a factor of ten.
the bandwidth is limited to 5 MHz.

ALT/CHOPP

⏚
Earth socket.

CHANNEL A

A/OFF/A–B
Selector switch with three positions:
A : The signal connected to channel A is displayed on the screen.
OFF : The signal connected to channel A is not displayed on the screen (but remains available for internal triggering).
A–B : The difference between the signals connected to channel A and to channel B is displayed on the screen. (Differential position).

POSITION
Vertical positioning of the display.

GAIN ADJ.
Screwdriver adjustment of the gain of the pre-amplifier of channel A, see section VII-A.

AMPL.
Control in steps of the vertical deflection coefficients.

AMPL – CAL (red)
Continuous control of the vertical deflection coefficients.
In the position CAL, the deflection coefficients are calibrated.

DC BAL	Screwdriver adjustment of the direct voltage balance of the Y amplifier of channel A, see section VII-A.
AC-0-DC	Selector switch with three positions: AC : Connection between input socket and input circuit via a blocking capacitor. 0 : Connection between input socket and input circuit is interrupted, and the amplifier input is earthed. DC : Direct connection between the input socket and the input circuit.
1 MΩ//20 pF	BNC input socket for channel A.
PROBE POWER	Power supply socket for active accessories.

CHANNEL B

B/OFF/–B	Selector switch with three positions: B : The signal connected to channel B is displayed on the screen. OFF : The signal connected to channel B is not displayed on the screen (but remains available for integral triggering). –B : The signal connected to channel B is displayed inverted on the screen.
POSITION	Vertical positioning of the display.
GAIN ADJ.	Screwdriver adjustment of the gain of the pre-amplifier of channel B, see section VII-A.
AMPL.	Control in steps of the vertical deflection coefficients.
AMPL – CAL (red)	Continuous control of the vertical deflection coefficients. In the position CAL, the deflection coefficients are calibrated.
DC BAL	Screwdriver adjustment of the direct voltage balance of the Y amplifier of channel B, see section VII-A.
AC-0-DC	Selector switch with three positions: AC : Connection between input socket and input circuit via a blocking capacitor. 0 : Connection between input socket and input circuit is interrupted, and the amplifier input is earthed. DC : Direct connection between the input socket and the input circuit.
1 MΩ//20 pF	BNC input socket for channel B.
PROBE POWER	Power supply socket for active accessories.

CATHODE RAY TUBE

INTENS	Brightness control of the trace.
FOCUS	Focusing of the electron beam.
ILLUM	Continuous control of the graticule illumination.
BEAMFINDER	A push-button control for decreasing the deflection coefficients to such an extent that signal traces are entirely visible on the screen.

CALIBRATION

CAL 600 mV - 2 kHz	BNC output socket on which a square-wave voltage of 600 mV with a frequency of 2 kHz is available. Ri = 100 Ω The output can be short-circuited to obtain a calibration current of 6 mA (PM 9040).

REAR SIDE OF THE INSTRUMENT

DEL.D. + GATE	BNC output socket on which the delayed gate pulses of +2 V are available.
MAIN TIME-BASE	BNC output socket on which the sawtooth voltage (0 to 8 Volt) of the main time-base is available.
⏚	Earth socket.
Z INPUT	
D.C. COUPLED (1 MΩ//20 pF)	d.c. input for modulating the trace brightness.
A.C. COUPLED (50 Ω)	a.c. input for modulating the trace brightness.

PM 3250X

Additional function description, see Fig. VI-2

1. X MAGN. PULL FOR x10	10x increase of the horizontal deflection coefficients by means of a pull-push switch.
2. PUSH FOR MAINS	A push-button for triggering the time-base with the mains frequency.
3. – VIDEO	This push-button must be pushed for negativ modulated television signals.
4. PULL FOR TV FRAME	This button must be pulled for triggering on tv field sync. signals.
5. /EXT. X	Input socket for external horizontal deflection.
6. X-DEFL. EXTERN	Switch position for external horizontal deflection.
7. –	Screwdriver adjustment for horizontal deflection attenuation. Fully clockwise is calibrated position (1 V/div.).
8. PULL FOR TV LINE	This button must be pulled for triggering on tv line sync. signals.

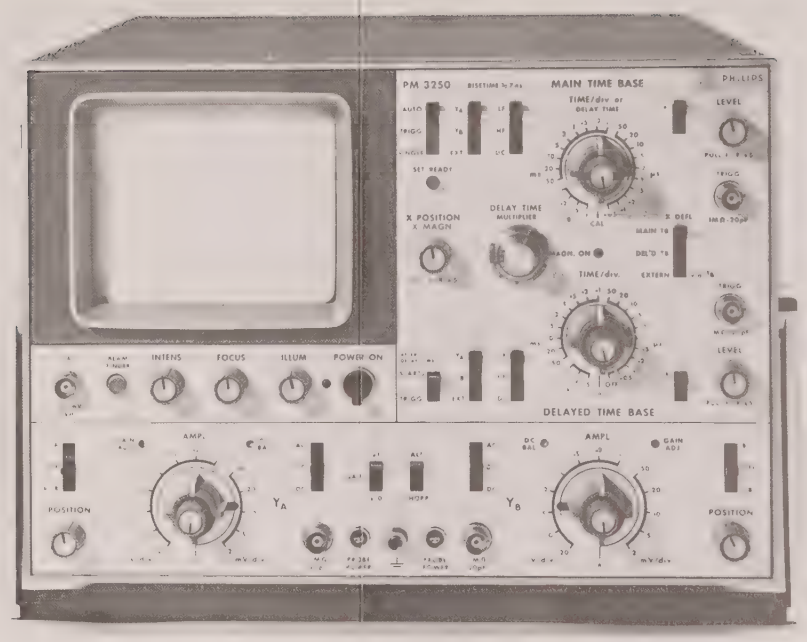

Fig. VI-1. Front panel controls

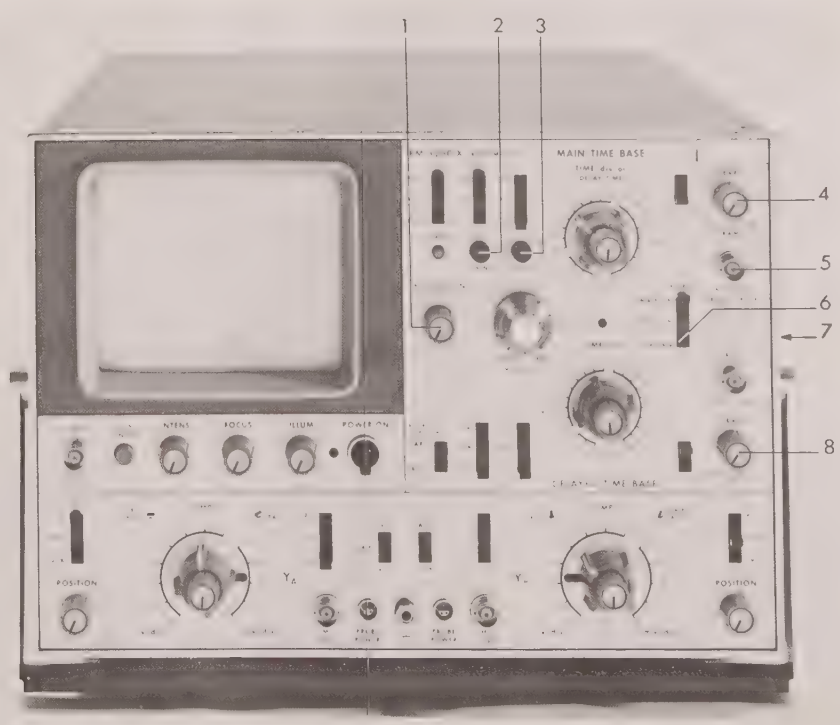

Fig. VI-2. Additional front panel controls PM 3250X

VII. Operation

A. PRELIMINARY SETTINGS

As the following settings are identical for both channels, only the procedure for channel A has been indicated.

1. Adjusting the DC balance

- Set switch A/OFF/A–B position A.
- Set switch AUTO/TRIGG/SINGLE to position AUTO.
- Set GAIN switch to position x1.
- Set AMPL switch to position 2 mV/div. and the continuous control to position CAL.
- Centre the trace by means of POSITION potentiometer.
- Adjust DC BAL so that the trace does not jump when the relevant AC/0/DC switch is switched between the 0 and the DC postions.
- Set switch GAIN to position x10 and readjust, if necessary.

2. Adjusting the gain

- Set switch AC/0/DC to position DC.
- Set switch GAIN to x1 position.
- Connect the CAL socket to the Y_A input socket.
- Set switch AMPL to position 0.1 V/div. and the continuous control to position CAL.
- Check that the trace height is exactly 6 divisions.
  If necessary, adjust with potentiometer GAIN ADJ.

B. GENERAL INFORMATION

1. AC/0/DC switch

The signals under observation are fed to the input sockets Y_A and/or Y_B, and switch AC/0/DC is set to either AC or DC depending upon the composition of the signal.
As the Y amplifier is d.c.-coupled, the full bandwidth of the instrument is available and d.c. components are displayed as trace shifts in the DC position of the AC/0/DC switch. This may be inconvenient when signals superimposed on high d.c. voltages have to be displayed. Any attenuation will result in attenuation of the a.c. signals.
The remedy is to use the AC position of the switch, which employs a blocking capacitor, to suppress the d.c. and low frequency signals (0 Hz to 3 Hz, –3 dB; with 10:1 probe, 0 Hz to 0,3 Hz). Some pulse droop will occur when low frequency, square-waves are displayed.
The 0 position interrupts the signal and earths the amplifier input for quickly determining the 0 V level.

2. A/OFF/A–B switch

When the switch is in position A, the signals applied to channel A are displayed in such a way that positive-going input signals cause an upward deflection on the screen.
In the OFF position the electronic switch of channel A is blocked, so that no input signal is fed to the output amplifier. It is, however, possible to use channel A for trigger purposes.
The intermediate amplifier is made differential. In position A of the A/OFF/A–B switch, one input is earthed. In position A–B, the differential mode, this earth is removed and the input signal of the channel B intermediate amplifier applied to this input.
Thus the difference of the signals of channels A and B will be displayed.
At the same time the signal of channel B, normal or inverted depending on the position of the B/OFF/–B switch, can be displayed. The position of this switch does not affect the signal which is applied to the differential amplifier, as this signal is taken off before.
For triggering in the differential mode, refer to the relevant section B.6.c.

3. B/OFF/−B switch

When this switch occupies position B, the signals applied to channel B are displayed in such way that positive-going input signals produce an upward deflection on the screen.
In the OFF position, the electronic switch of channel B is blocked, so that no input signal is fed to the output amplifier. It is, however, possible to use channel B for trigger purposes.
In position −B, the signals applied to channel B are displayed in such way that positive-going input signals produce a downward deflection on the screen.

4. ALT/CHOPP switch

In the ALT position, the display is switched over from one channel to the other at the end of the linear part of the sawtooth of the main time-base.
In position CHOPP, the display is switched over from one channel to the other with a fixed frequency.

5. GAIN switch

In position x10 of this switch, the sensitivity of both vertical channels is increased by a factor 10.
The bandwidth in this position is limited to 5 MHz.
An important advantage in this position is also that the positioning range of the POSITION potentiometers is increased from 24 divisions to 160 divisions, as the GAIN switch is incorporated in the circuit after the position controls.

Example:
A deflection factor of 20 mV/div. can be obtained by setting the AMPL switch to position 20 mV/div., or by setting the AMPL switch to position .2 V/div. and the GAIN switch to position x10.
In the former case the positioning range is 24 divisions and the latter case 160 divisions, however with reduced bandwidth. Where very small signals, superimposed on large signals are to be examined, the second possibility is very useful as long as the limited bandwidth is not unacceptable.

6. Triggering

a. General

If a signal must be displayed, the horizontal deflection must always be started on one fixed point of the signal in order to obtain a stationary display. The time-base is, therefore, started by narrow trigger pulses formed in the trigger unit, controlled by a signal originating from one of the vertical input signals or an external source.

b. Trigger Coupling

Three different trigger coupling methods can be chosen with switch LF/HF/DC. The LF and HF positions limit the transfer characteristic.
In position LF, a 3 Hz to 1 MHz band-pass filter is inserted. This position can be used to reduce interference from noise.
In position HF, a 2 kHz high-pass filter is inserted. This position can be used to reduce interference from, e.g. hum.
In position DC, finally, the trigger signal is passed unchanged.

c. Selecting the trigger source and setting the trigger level

The trigger signal is obtained from channel A (position Y_A), channel B (position Y_B), or from an external source (position EXT), depending on the position of switch Y_A/Y_B/EXT. In the differential position of the vertical amplifier, the A−B trigger signal is originated in the trigger pick-off stage itself.
The trigger pulse shaper is a dual-controlled multivibrator switched by the output signals of a difference amplifier.
The trigger signal (which is not affected by the AMPL. continuous control) is fed to one input of the difference amplifier; and a direct voltage adjustable with the LEVEL potentiometer is fed to the other input. Depending on this LEVEL setting, the selected part of the trigger signal will be amplified by means of the difference amplifier; and the multivibrator is thus switched at a fixed point of the trigger signal (see Fig. VII-1). This means that, with the aid of the LEVEL control, it is possible to scan the shape of the trigger signal (in case of internal triggering, equal to the shape of the signal to be displayed), and thus to choose the point where the multivibrator will be switched.
The LEVEL potentiometer is fitted with a pull-push switch which allows a 5-fold range increase to be used for large trigger signals.

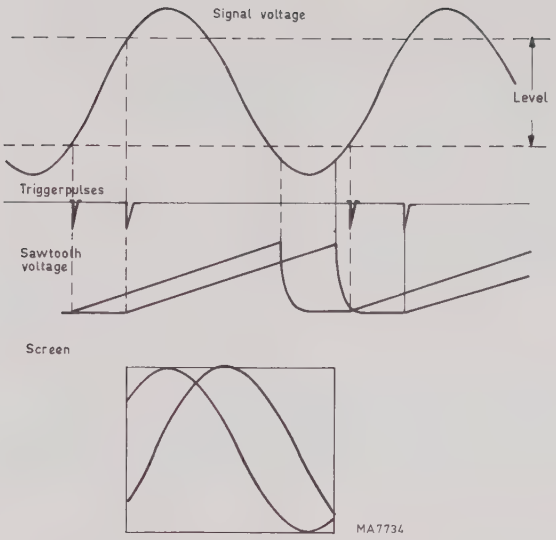

Fig. VII-1. Scanning the waveform to be studied by means of the LEVEL potentiometer

d. Trigger polarity

With the aid of trigger polarity switch +/—, triggering is possible, chosen on the positive-going or negative-going edge of the trigger signal.

e. Automatic triggering

When the switch AUTO/TRIGG/SINGLE is in the position AUTO, and if there are no trigger pulses available, the time-base generator is automatically free-running. The trace is, therefore, always visible.
This position can be used in all cases where also TRIGG is usable except with reference frequencies lower than 2 Hz. As soon as trigger pulses are available, the free-running state of the time-base is automatically terminated and the time-base is triggered again, as described in points b, c, d. In the positions TRIGG and SINGLE, the auto-circuit is switched off. The LEVEL setting can also be used in position AUTO of switch AUTO/TRIGG/SINGLE.

7. Position SINGLE and use of the SET READY push-button

When effects which occur only once have to be observed (usually photographed), it is often desirable to ensure that only sawtooth is generated, even though several trigger pulses might be produced after the phenomenon of interest. Of course, the single sawtooth in question must be triggered by a trigger pulse. To this end the mode switch must be put into position SINGLE. When the SET READY button has been pressed, the first following trigger pulse that appears after this button has been released will start the time-base generator. The trace is only written once. The time-base is then blocked until the SET READY push-button is again operated.
The lamp in the SET READY push-button, will light up as soon as this button is released and will go out as soon as the sawtooth is terminated.

8. X MAGN switch

The X MAGN switch is two-position pull-push type.
In position x5, the horizontal deflection is increased by a factor of 5, except when X DEFL switch is in EXTERN via YB position. Thus the portion of the signal displayed in the two central horizontal divisions in the x1 position, occupies the full width of the screen in the x5 position. Any portion of the trace can be brought on to the screen by the X POSITION control for scrutinisation.
In the x5 position, the sweep time of the sawtooth is determined by dividing the indicated TIME/div. value by 5.

9. Use of the delayed time-base

The delayed time-base can be used for accurate time measurements, (see Chapter VIII-C4) and for the accurate study of complex signals.

In the STARTS position of the AFTER DELAY TIME switch, immediately the delayed time-base is on i.e., (TIME/div. switch is not at OFF), a portion of the displayed signal is intensified in the MAIN TB position of the X DEFL switch. The DELAY TIME MULTIPLIER enables this intensified portion to be shifted along the time axis. The duration of the intensified portion, its length, can be controlled in steps and also continuously, by the TIME/div. controls of the delayed time-base. When the X DEFL switch is in the DEL'D TB position, the intensified portion occupies the full width of the screen.
In the DEL'D TB position of the X DEFL switch, the product of the main TIME/div. switch setting and the setting of the DELAY TIME MULTIPLIER determines the delay time; i.e., the interval between the starting point of the main time-base and the starting point of the delayed time-base.
In the TRIGG position of the AFTER DELAY TIME switch, the delayed time-base is started by the first trigger pulse that occurs after the selected delay time.
This trigger pulse is supplied by the trigger unit of the delayed time-base. This position is used when time jitter would otherwise give a blurred image of the detail under observation. This time jitter could be part of the signal being investigated or, at extreme magnifications, initiated by the time-base circuits.

10. External X deflection

If switch X DEFL is in the EXTERN via Y_B position, both time-bases will be switched off. The signal of channel B is horizontally displayed, over a bandwidth of 5 MHz.
Except for the GAIN switch, all controls of channel B remain operative.
The X POSITION and X MAGN controls are switched off; for positioning the trace the POSITION control of the B channel is employed.

11. Brightness modulation

To obtain extra information on a display, the brightness can be modulated by an external voltage.
The external voltage must be fed to one of the Z MOD sockets at the rear of the instrument. The amplitude required to achieve visible brightness modulation depends on the position of the INTENS potentiometer.
With normal picture brightness, a 5 $V_{p\text{-}p}$ amplitude is able to obtain good visible brightness modulation.
Two input sockets are available, a high impedance DC COUPLED socket and a low impedance AC COUPLED socket.

PM 3250X ADDITIONAL OPERATING INSTRUCTIONS

A. USE OF THE SYNC. SEPARATOR

TV field triggering

- Connect the composite video signal to a Y input.
- Set the relevant AMPL. switch to a position which provides a convenient display amplitude (0.5 div. will be sufficient for stable triggering).
- Set the main time-base Y_A/Y_B/EXT trigger switch to its relevant position.
- Operate the PULL FOR TV FRAME switch.
- Set the main time-base +/– switch to its + position (independent of the polarity of the video signal).
- For negative-modulated video signals depress the PUSH FOR – VIDEO switch.
  A field sync. triggered display is now obtained.

TV line triggering

If triggering on a certain TV line is required, proceed as follows:
- Obtain stable triggering on the complete frame as detailed in the above procedure.
- Using the delayed time-base TIME/div. and the Delay time Multiplier controls, intensify the particular line(s).
- Operate the PULL FOR TV LINE switch.
- Set the STARTS/TRIGG. switch to the TRIGG. position.
- Set the delayed time-base +/– switch to + position.
- Transfer the X DEFL. switch to its DEL'D TB position in order to present a full-screen display of the intensified portion.

The X MAGN. switch (x10) may be used for more detailed study of line information.
Note that when the delayed time-base is used to display a single TV line as described above, the ambient light conditions may make it advisable to use the collapsible viewing hood PM 9366.

– If main time-base triggering on a unselected TV line is required, normal triggering should be used instead of the built-in sync. separator.
The LF/HF/DC must be in the DC position. Use the +/– switch and the LEVEL control.

B. MAINS TRIGGERING

– Operate the PUSH FOR MAINS switch in order to inject a mains frequency signal into the main time-base.
Note that selection of the mains triggering facility automatically disables the other main time-base triggering sources (also the sync. separator is switched off).
The +/– switches are normally in use.

C. EXTERNAL HORIZONTAL DEFLECTION

– Connect the external deflection signal source to the TRIGG./EXT. socket of the main time-base.
– Set the X DEFL. switch to its EXTERN position.
Set the ALT./CHOPP. switch to its CHOPP. position.
The X MAGN. switch and the preset potentiometer (R20) on the right-hand side of the cabinet, are used in order to set the deflection factor for the external horizontal input signal. With the X MAGN. switch set to its x1 position, the range of the external horizontal preset potentiometer is 1 V/div. to 5 V/div. (0.1 V/div. to 0.5 V/div. if the X MAGN. switch is set to x10). The preset potentiometer must be set to its fully-clockwise position if calibrated operation of the X MAGN. switch is required.
– The display can be shifted with the X POSITION control.

Important

1. If the sync. separator is used, always put the +/– trigger switches in the + position.
2. If both Y channels have to be used, together with an external horizontal input signal, the ALT./CHOPP. switch must be in the CHOPP. position.

VIII. Applications

A. INTRODUCTION

The following information describes the basic measuring techniques for use with the PM 3250 oscilloscope. Before connecting an input to the oscilloscope, locate the beam as follows:

– Connect the apparatus to the mains and switch on
– Set all switches to their upper positions and all potentiometers to their mid positions
– Use the BEAMFINDER push-button in conjunction with the POSITION controls to display the beam

Optimum graticule and waveform display conditions can then be set using the INTENS, FOCUS, and ILLUM controls. Maximum accuracy is obtained by setting up a waveform which is as large as possible.

Whenever a reading is taken from an AMPL or TIME/div. control, it is important that the associated potentiometer in its CAL position, otherwise the switch setting will not have the exact value shown on the calibrated scale.

When the GAIN switch is set to x10, the bandwidth of the oscilloscope is limited to 5 MHz and sensitivity is increased by a factor of 10. Maximum sensitivity is 200 μV/div.

B. VOLTAGE MEASUREMENTS

1. Peak-to-peak measurements

– Connect the signal to the Y_A input socket
– Set the GAIN switch to x1
– Set the AC/0/DC switch of channel A to AC (or to DC if the signal under examination has a frequency of less than 10 Hz)
– Set the A/OFF/A–B switch to A, and the B/OFF/–B switch to OFF
– Set the AUTO/TRIGG/SINGLE switch to AUTO
– Set the Y_A/Y_B/EXT switch to Y_A
– Set the HF/LF/DC switch to the appropriate position, depending upon the frequency of the signal
– Set the X DEFL switch to MAIN TB
– Set the AMPL potentiometer to its CAL position. Do not disturb this setting until the measurement procedure has been completed
– Use the POSITION control of channel A to shift the trace until it is written symmetrically about the horizontal centre-line of the graticule
– If necessary, use the X POSITION control to centre the signal
– Obtain the largest possible display using the AMPL switch of channel A
– With the TIME/div. switch of the delayed time-base set to OFF, set the TIME/div. switch of the main-time base to a position at which several cycles of the signals can be seen. If necessary, adjust the main time-base LEVEL control in order to obtain a stable trace
– Using the POSITION control of channel A, align the upper peaks of the waveform with the nearest horizontal graticule line, as shown in Fig. VIII-1.
– Align one of the lower peaks with the vertical centre-line of the graticule.
– Measure the height of the waveform using the graduations of vertical graticule line
– Multiply the distance obtained by the deflection coefficient at which the AMPL control is set, and by the attenuation factor of the probe (if any) in order to obtain the peak-to-peak value of the waveform.

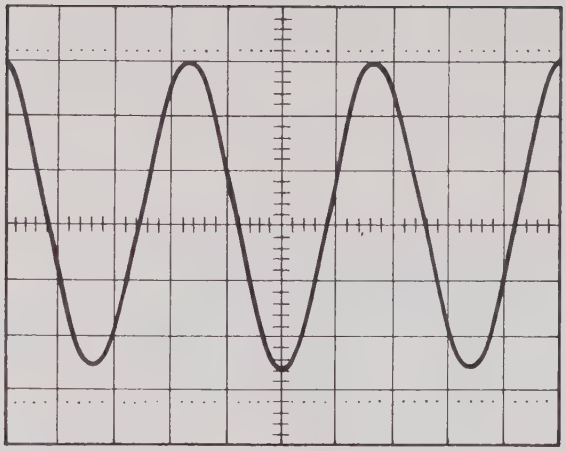

Fig. VIII-1. Peak-to-peak voltage measurement, with one lower peak aligned with the vertical centre-line and the upper peaks aligned with a horizontal graticule line

2. R.M.S. voltage measurements

The r.m.s. value of a sinusoidal waveform may be found as follows:
– Determine the peak-to-peak value of the waveform using the method described in the above paragraph
– Calculate the r.m.s. value by inserting the peak-to-peak value in the formula quoted below:

$$V_{r.m.s.} = \frac{V_{p\text{-}p}}{2\sqrt{2}} \approx 0{,}35\ V_{p\text{-}p}$$

3. Instantaneous voltage measurements

The following procedure can be used to measure instantaneous voltage:
– Connect the signal to the Y_A input socket
– Set the A/OFF/A–B switch to A and the B/OFF/–B to OFF
– Set the AUTO/TRIGG/SINGLE switch to AUTO
– Set the Y_A/Y_B/EXT switch to Y_A
– Set the LF/HF/DC switch to the appropriate position, depending upon the frequency of the input signal
– Use the POSITION control of channel A to display the signal about the horizontal centre-line
– If necessary, place the signal by means of the X POSITION control
– Turn the AMPL potentiometer of channel A to its CAL position.
Do not disturb this setting until the measuring procedure has been completed
– Set the AMPL switch of channel A to the position at which the largest possible display is obtained
– Set the AC/0/DC switches of both channels to '0'. The trace becomes linear
– Using the Y_A POSITION control, align the trace with a suitable horizontal graticule line. This horizontal graticule line will become the reference level, so that it should be located in a position to suit the waveform which is displayed when the AC/0/DC switch of channel A is set to DC.
– Set the B/OFF/–B switch to B in order to display a second horizontal trace which may be used to illuminate the graticule chosen as the reference level
– Use the Y_B channel POSITION control to align the two horizontal traces. Note that it is important to use the Y_B POSITION control for alignment of the two traces.
– Set the AC/0/DC switch of channel A to DC. The waveform will now be displayed, together with the horizontal line which marks the reference level. It is extremely important not to disturb the POSITION switches of the two channels, otherwise the true reference level may be lost.
– Adjust the main time-base LEVEL control in order to obtain a stable display
– With the TIME/div. switch of the delayed time-base set to OFF, set the main time-base TIME/div. switch to a position which provides a suitable display

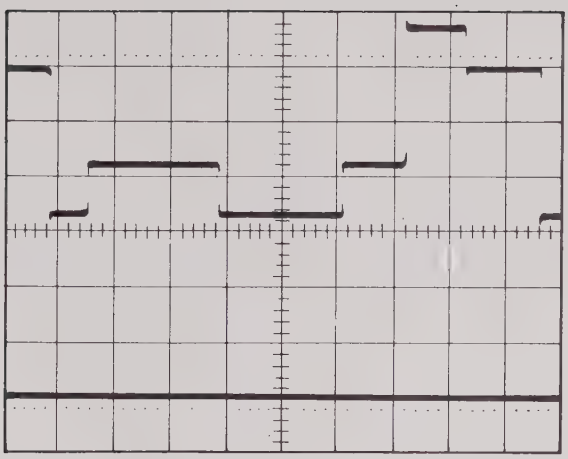

Fig. VIII-2. Instantaneous voltage measurement using the line written by channel Y_B as a reference marker

- Use the X POSITION control to align the instantaneous voltage point which has to be measured, with the vertical centre-line of the graticule, as shown in Fig. VIII-2.
- Record the number of divisions that separate the instantaneous voltage point from the reference line
- Prior to the conclusion of the measurement it is advisable to check the accuracy of the reference level by setting the AC/0/DC switch of channel A to 0. If the reference level is correct, the two horizontal traces should merge so that they appear to be one line on the display. If this is not the case, repeat the whole measurement procedure

The value of the instantaneous voltage may be calculated by multiplying the vertical distance between the instantaneous voltage point and the reference level, by the deflection coefficient to which the AMPL switch has been set, and by the attenuation factor of the probe (if used). If the instantaneous voltage point appears above the reference line, it is positive: negative potentials are displayed below the reference line

If an instantaneous voltage is to be measured with respect to a second (reference) voltage, proceed as follows:

- Connect and set up the signal as described in the first nine steps of the above procedure
- Temporarily disconnect the signal from the Y_A input socket and connect the reference signal
- Align the reference level with a suitable horizontal graticule line
- Set the B/OFF/−B switch to B in order to display a horizontal trace which may be used to mark the reference level. Use the Y_B channel POSITION control to align the two traces.
- Disconnect the reference signal. Note that, since the reference signal has been disconnected, there is no easy means by which the reference level displayed by channel B can be checked. It is, therefore, most important that the POSITION controls of both channels are not disturbed until the measurement procedure has been completed
- Reconnect the signal to the Y_A input socket
- Calculate the voltage value by multiplying the vertical distance between the instantaneous voltage point and the reference level by the deflection coefficient to which the AMPL switch is set, and by the attenuation factor of the probe (if used)

C. TIME AND FREQUENCY MEASUREMENTS

1. Introduction

The following section describes those techniques employed to evaluate time differences between signals, and to establish the frequency of a displayed waveform. Two waveforms can only be displayed in a manner suitable for time difference measurements provided that they are either of the same frequency, or if the frequency of one waveform is a multiple of the other.
In order to determine the expected accuracy of a time or frequency measurement, the following sources of possible error should be considered:

a. Main and delayed time-bases. With the TIME/div. potentiometer set to CAL, the time-base may cause a possible error of ±3 % in any reading taken over the middle eight horizontal divisions of the horizontal graticule. If the selected deflection coefficient is either 1 s/div., 0.5 s/div., or 0.2 s/div., then the maximum time-base error is increased to ±5 %.

b. The 'PULL FOR x5' MAGN switch. Use of this switch adds a further ±2 % to the possible error quoted in sub para (a).

c. Read-off error. The maximum absolute read-off error is considered to be 0,05 divisions per read-off (i.e. readings taken between two points on the graticule may involve a total possible read-off error of 2 x 0,05 = 0,1 divisions). When expressed as a percentage, the read-off error is inversely proportional to the number of divisions over which the reading has been taken.

d. DELAY TIME MULTIPLIER control. When a number of vernier digits has been counted from this control, a total absolute read-off error of 0,010 digits (0,005 digits per read-off) is possible.
This error is made inversely proportional to the number of digits counted, when expressed as a percentage.

e. DELAY TIME MULTIPLIER non-linearity. Non-linearity of this control amounts to ±0,1 %.

2. Time measurements using the main time-base

The following procedure can be used to determine the time difference between two points on a waveform:

– Connect the signal to be examined to the Y_A input socket
– Set the A/OFF/A–B switch to A, and the B/OFF/–B to OFF
– Set the GAIN switch to x1
– Set the AUTO/TRIGG/SINGLE switch to AUTO
– Set the Y_A/Y_B/EXT switch to Y_A
– Set the HF/LF/DC switch to the appropriate position, depending upon the frequency of the input signal
– Set the X DEFL switch to MAIN TB
– Set the AMPL switch in order to obtain as large a signal as possible.
Adjust the main time-base triggering controls in order to obtain a stable display
– Set the main time-base TIME/div. potentiometer to its CAL position
– Set the main time-base TIME/div. switch to a position which provides the greates possible horizontal distance between the measuring points.
In the interests of accuracy, it is advisable not to use the first and last divisions of the graticule
– Using the X POSITION control, align one of the measuring points with the nearest vertical graticule line
– Use the Y_A channel POSITION control to align the other measuring point with the horizontal centre-line of the graticule shown in Fig. VIII-3.
– Check that the first measuring point has not strayed during the Y_A position control operation
– Measure the horizontal distance (⟵ t ⟶) between the two measuring points
– Calculate the time period by multiplying the horizontal distance between the two measuring points, by the deflection coefficient to which the main time-base TIME/div. switch is set. Divide the product by five only if the MAGN switch has been operated.

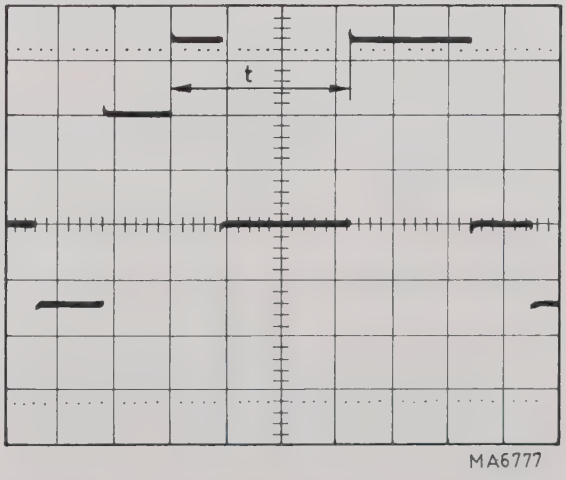

Fig. VIII-3. Main time-base time measurement with one measuring point aligned with a vertical graticule and the other measuring point aligned with the horizontal centre-line.

3. Time difference measurements between two separate pulses using the main time-base

The time difference between two separately displayed pulses may be evaluated with the aid of the PM 3250 oscilloscope. It should be noted, however, that the oscilloscope can only present a stable display of two separate waveforms if the frequency of one waveform is a multiple of the other.
The method used to measure the time difference between the respective edges of two separately display pulses is as follows:

- Connect the two signals to the Y_A and Y_B input sockets using probes or coaxial leads with identical time delay properties
- Set the AC/0/DC switches to the position which are best suited to the input signals
- Set the CHOPP/ALT switch to CHOPP for low frequencies, or to ALT for high frequencies
- Set the A/OFF/A–B switch to A, and the B/OFF/–B switch to B. If the signals show opposite polarity, the necessary inversion can be made by transferring the B/OFF/–B switch to the –B position
- Set the Y_A/Y_B/EXT to the channel (Y_A or Y_B) which carries the signal which leads in time
- Adjust the main time-base triggering controls for a stable display
- Set the TIME/div. potentiometer of the main time-base to its CAL position, before setting the associated TIME/div. switch to the setting which provides the greatest horizontal distance between the measuring points
- Use the POSITION controls of the two channels to position the two traces symmetrically about the centre-line of the graticule
- Using the X POSITION control, shift the display until one of the measuring points passes through a junction formed by a vertical graticule line and the horizontal centre-line shown in Fig. VIII-4.
- Measure the horizontal distance (⟵ t ⟶) between the two measuring points by means of the graduated horizontal centre-line
- Multiply the measured horizontal distance by the deflection coefficient to which the main time-base TIME/div. switch is set.
  Divide this product by five only if the MAGN switch has been operated.

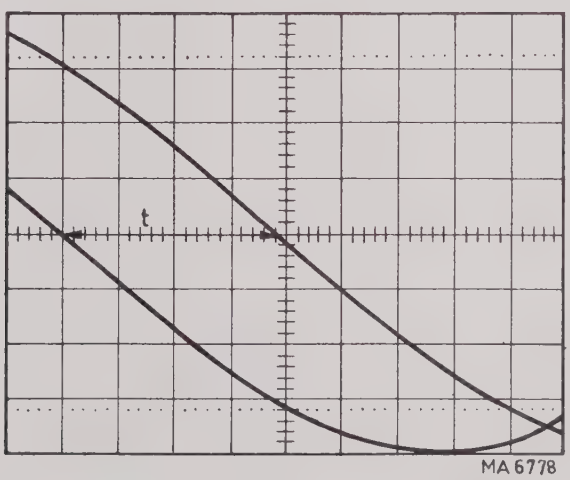

Fig. VIII-4. Separately displayed signals shifted so that one time difference measuring point passes through the junction formed by a vertical graticule line and the horizontal centre-line

4. Time measurements using the delayed time-base

a. General information

With the X DEFL switch set to MAIN TB, the DELAY TIME MULTIPLIER can be used in conjunction with the delayed time-base TIME/div. switch, to intensify a given portion of the displayed waveform.
An enlarged presentation of this intensified portion is obtained when the X DEFL switch is set to DEL'D TB. This facility is particularly useful for making accurate pulse width measurements.
The width of one or more displayed pulses may be accurately evaluated by recording the number of calibrated DELAY TIME MULTIPLIER divisions required to shift the pulse or pulses across a reference graticule. The recorded number of divisions, when multiplied by the main time-base TIME/div. switch setting, provides the pulse width time.

This method enables use of the delayed time-base TIME/div. potentiometer so that an exact portion of the waveform can be chosen for enlarged display.
Assume that it is required to calculate the width between points P_1 and P_2 shown in Fig. VIII-5.
The intensified portion is shown in Fig. VIII-6. and the enlarged display, obtained when the X DEFL switch is set to DEL'D TB, is shown in Fig. VIII-7. Firstly, point P_1 is aligned with the vertical centre-line of the graticule (Fig. VIII-8).
The DELAY TIME MULTIPLIER is then used to shift the waveform across the screen until point P_2 is aligned with the vertical centre-line of the graticule (Fig. VIII-9). The recorded number of DELAY TIME MULTIPLIEF divisions, when multiplied by the main time-base TIME/div. switch setting, provides the pulse width time.
An alternative method involves counting the number of graticule divisions which separate the two measuring points. The delayed time-base TIME/div. switch setting can then be used to evaluate the pulse width, it is imperative that the delayed time-base TIME/div. potentiometer is set to its CAL position throughout the procedure, otherwise the deflection coefficient setting will not be accurate.

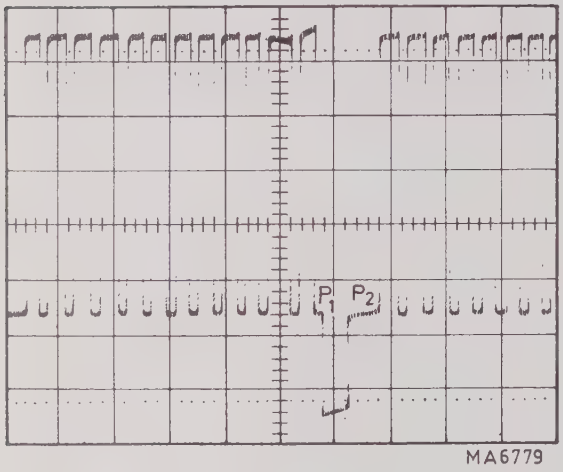

Fig. VIII-5. Basic waveform

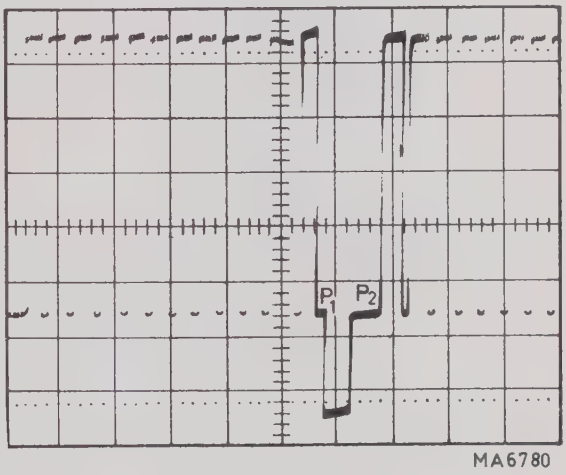

Fig. VIII-6. Intensified portion of basic waveform

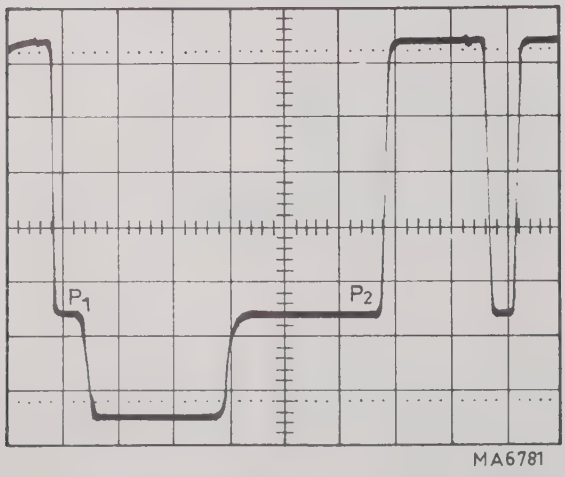

Fig. VIII-7. Enlarged display of the intensified portion obtained by setting the X DEFL switch to DEL'D TB

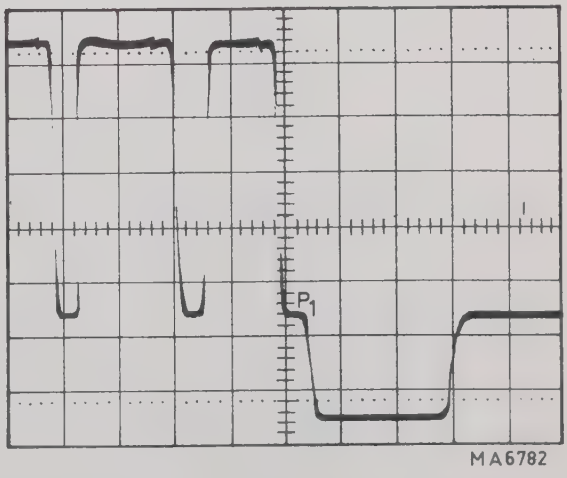

Fig. VIII-8. Point P_1 aligned with the vertical centre-line of the graticule (DELAY TIME MULTIPLIER control reads 5.17)

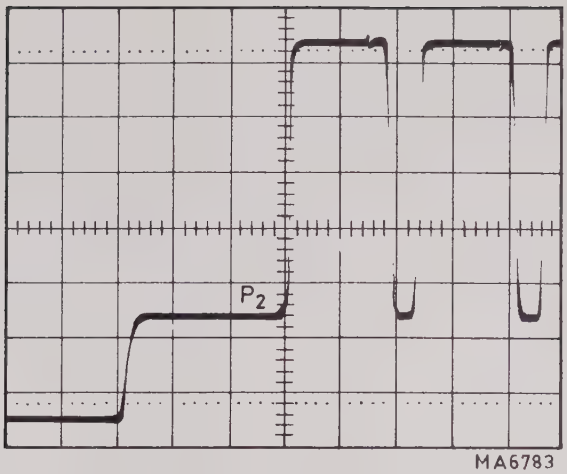

Fig. VIII-9. Waveform shifted across the screen until point P_2 is aligned with the vertical centre-line of the graticule (DELAY TIME MULTIPLIER control reads 6.32)

b. Using the DELAY TIME MULTIPLIER

To measure a pulse width using the DELAY TIME MULTIPLIER, proceed as follows:

- Connect the signal to the Y_A input socket
- Set the A/OFF/A-B switch to A, and the B/OFF/-B switch to OFF
- Set the AUTO/TRIGG/SINGLE switch to AUTO
- Position the display symmetrically about the centre-line of the graticule
- Set the AMPL switch of channel A to the position which provides the maximum possible display within the viewing area
- Set the main time-base TIME/div. potentiometer to its CAL position
- Adjust the triggering controls to obtain a stable display
- Set the AFTER DELAY TIME switch to the STARTS position
- Using the DELAY TIME MULTIPLIER control in conjunction with the delayed time-base TIME/div. switch and potentiometer, intensify the portion of the waveform which is to be examined
- Transfer the X DEFL switch from the MAIN TB to the DEL'D TB position. An enlarged display of the intensified portion of the waveform will be presented
- Use the DELAY TIME MULTIPLIER control to align the left hand measuring point with the vertical centre-line of the graticule.
  Note the reading of the DELAY TIME MULTIPLIER control
- Rotate the DELAY TIME MULTIPLIER control until the right hand measuring point is aligned with the vertical centre-line. Note the new reading
- Subtract the smaller DELAY TIME MULTIPLIER reading from the larger.
  Multiply the resulting difference by the main time-base TIME/div. switch setting, in order to obtain the pulse width time. The answer must be divided by five only if the MAGN switch has been used.

c. Using the graticule

To measure the pulse width by means of the graticule (instead of using the DELAY TIME MULTIPLIER) proceed as follows:

- Set up the signal in accordance with the first ten steps of the above procedure, but keep the TIME/div. potentiometers of both the main and delayed time-bases in their CAL positions
- Use the X POSITION control to shift the left hand measuring point so that it is aligned with a convenient point on the horizontal centre-line of the graticule
- Count the number of horizontal divisions which separate the two measuring points. Multiply the number of divisions by the deflection coefficient to which the delayed time-base TIME/div. switch is set. Multiply this answer by five only if the MAGN switch has been operated.

5. Rise time measurements

a. General information

The rise time of a pulse is defined as the period of time taken for the leading edge of the pulse to rise from 10 % to 90 % of its total amplitude, as shown in Fig. VIII-10.
Reference to the oscilloscope graticule will show two dotted lines, which are the 10 % to 90 % points of the vertical scale. If, therefore, a leading edge is displayed in such a way that its peak is aligned with the top most horizontal graticule line and its lower level aligned with the bottom horizontal graticule line, then the dotted lines indicate the 10 % and 90 % values of the edge. In many cases, it is required to measure a rise time which is of the same order as that of the oscilloscope. In such cases, subject to the conditions discussed below, the actual rise time of the pulse can be calculated with the aid of equations having the following general form:

$$T_{ra} = \sqrt{T_{rm}^2 - T_{ro}^2}$$

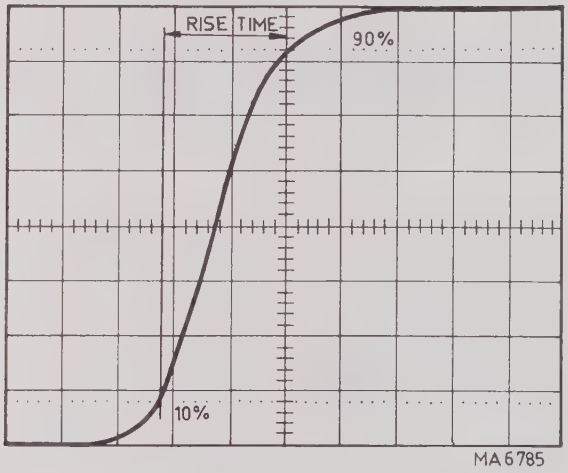

Fig. VIII-10. Definition of rise time

where T_{ra} is the actual rise time, T_{rm} the measured rise time, and T_{ro} the rise time of the oscilloscope (nominally 7 ns at x1 gain and 70 ns at x10 gain). Maximum rise time measurement accuracy will be obtained by observing the following conditions:
Rise time measurements made with the GAIN switch at x1

No correction formula need be applied if a rise time (measured with the aid of the dotted 10 % and 90 % reference lines) is greater than three times the nominal rise time of the instrument, i.e. 21 ns.
This is due to the fact that the measured rise time is only expected to be 5 % greater than the actual rise time of the signal.
In those cases where the measured rise time is equal or greater than 10 ns, but is less than 21 ns, then the influence of the oscilloscope rise time is significant. The following formula must therefore be used in order to apply correction to the measured rise time:

$$T_{ra} = \sqrt{T_{rm}^2 - T_{ro}^2}$$

If an accurate result is required from a measured rise time of less than 10 ns, then the rise time of the oscilloscope must be measured.

This can be done by applying the following procedure:

- Set up a display which is suitable for making a rise time measurement, then temporarily disconnect the input signal
- Connect a fast pulse generator to the input socket, taking care not to disturb any settings of the oscilloscope

Note that the degree of accuracy obtained from this procedure is largely dependent upon the rise time of the fast pulse generator. The rise time of the fast pulse generator must, therefore, be extremely small when compared with 7 ns (i.e. the rise time of the oscilloscope)

– Set the output voltage of the fast pulse generator to the exact amplitude of the input signal display. For example, assuming that the rise time of the signal examination is to be measured over the full eight divisions of the graticule, the output voltage of the fast pulse generator must be set to give an eight division display. Measure the rise time of the displayed pulse, which will be almost the rise time of the oscilloscope in the particular setting. Record this rise time.
– Disconnect the fast pulse generator and reconnect the input signal
– Measure the rise time of the signal
– Calculate the actual rise time of the signal using the formula:

$T_{ra} = \sqrt{T_{rm}^2 - T_{rop}^2}$, where T_{rop} is the actual rise time of the particular oscilloscope, as measured with the fast pulse generator.

Rise time measurements made with the GAIN switch set to x10.
Rise time measurements are rarely made with the oscilloscope operating in the x10 mode. However, if a circumstance arises in which it is desirable to set the GAIN switch to its x10 position, the conditions specified above for x1 GAIN settings can be followed.
It must, although, be remembered that the oscilloscope rise time will be 70 ns (i.e. ten times the rise time of the oscilloscope operating in the x1 mode).

b. Rise time measurements using the main time-base

The following method can be used to determine the rise time of a waveform in which all pulses are identical, both in shape and in period. If the rise time of particular pulse in an irregular waveform is to be measured, then use the delayed time-base method which is detailed in para c.

– Connect the signal to the Y_A input socket
– Set the A/OFF/A–B switch to A, and the B/OFF/–B switch to OFF
– Set the AUTO/TRIGG/SINGLE switch to AUTO
– Set the LF/HF/DC switch to the appropriate position, depending upon the frequency of the signal
– Set the main time-base TIME/div. switch to its CAL position
– Adjust the main time-base trigger controls for a stable display
– Set the main-time base TIME/div. switch to a position which enables one complete edge of the pulse shape to be displayed
– Using the Y_A POSITION control in conjunction with the AMPL switch and AMPL potentiometer, obtain a condition in which the pulse shape begins at the bottom horizontal graticule line and ends at the top graticule line (i.e. the vertical deflection rises through exactly eight horizontal divisions). Make any necessary adjustment to the ILLUM and INTENS controls in order to make the display clear, shown in Fig. VIII-10.
– Further expand the trace in the horizontal plane, by means of the main time-base TIME/div. switch. Stabilize the display using the LEVEL potentiometer
– Pull the MAGN switch when its effect will reduce read-off error
– Use the X POSITION control to gradually shift the display until the edge of the pulse shape coincides with a junction of the dotted 90 % line and a vertical graticule. Check that, with the trace so positioned, the intersection of the trace and the dotted 10 % line is still visible. The vertical graticule line which forms the junction with the dotted 90 % line and the trace edge is now the time reference point, so that no readjustment of the X POSITION control must be made
– Check, by means of the main time-base TIME/div. switch, that the trace still has an amplitude of exactly eight divisions before measuring the horizontal distance between the points at which the edge intersects the dotted 10 % and 90 % reference lines

Calculate the measured rise time by multiplying the horizontal distance by the deflection coefficient to which the TIME/div. switch is set.
Divide this product by five only if it has been necessary to use the MAGN switch.
If the measured rise time is of the same order as that of the oscilloscope, then use the formula quoted at the beginning of this paragraph to evaluate the actual rise time of the signal, which may be considerably less than the measured rise time (see introductory paragraphs).
For example, with a TIME/div. setting of 0.05 μs, a GAIN switch setting of x10, and a measured horizontal separation of 3,4 divisions, the measured time rise will be:

$$T_{rm} = 3{,}4 \times 50 \text{ ns} = 170 \text{ ns}$$

Since the GAIN switch is set to x10, the rise time of the oscilloscope is 70 ns which is significant when compared with the measured rise time.

The actual rise time must therefore be calculated, as follows:

$$T_{ra} = \sqrt{T_{rm}^2 - T_{ro}^2}$$
$$= \sqrt{170^2 - 70^2} \qquad = 155 \text{ ns}$$

c. Rise time measurements using the delayed time-base

The following procedure is used when it is required to identify a particular pulse from a series, in order to measure its rise time or to examine it in detail.

- Connect the signal to the Y_A input socket
- Set the A/OFF/-B switch to A, and the B/OFF/-B switch to OFF
- Set the AUTO/TRIGG/SINGLE switch to AUTO
- Set the delayed time-base TIME/div. potentiometer to its CAL position
- Using the main time-base TIME/div. switch and potentiometer, display the required train of pulses on the screen
- Use the Y_A POSITION control in conjunction with the AMPL switch and AMPL potentiometer of channel A, to adjust the display until it is large enough for a detailed examination
- Set the TIME/div. switch of the delayed time-base to the smallest possible deflection coefficient which may be used to obtain an intensified portion of the waveform of the same width as the pulse under examination
- Use the DELAY TIME MULTIPLIER to shift the intensification to the pulse which is to be examined. See Fig. VIII-11.

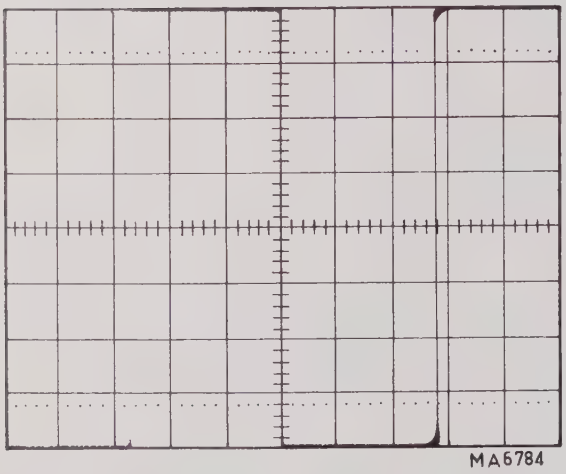

Fig. VIII-11. Square wave pulse with one edge intensified for the purpose of rise time measurement

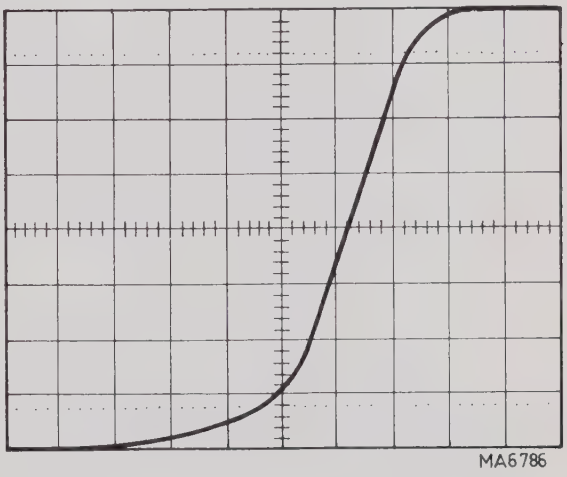

Fig. VIII-12. Enlarged display of the intensified edge which is obtained when the X DEFL switch is set to DEL'D TB

- Set the MAIN TB/DEL'D TB/EXTERN switch to DEL'D TB. The selected pulse will now be displayed
- Use the Y_A POSITION control in conjunction with the AMPL switch and AMPL potentiometer, to obtain a condition in which the edge of the displayed pulse begins on the bottom horizontal graticule line and ends at the top graticule line (i.e. the vertical deflection rises through exactly eight horizontal graticule divisions)
- Further expand the display in a horizontal plane by means of the delayed time-base TIME/div. switch. Stabilize the display using the main time-base LEVEL control. Stabilization is also possible using the main time-base triggering controls when the AFTER DELAY TIME switch is transferred from STARTS to TRIGG. See Fig. VIII-12.
- Use the X POSITION potentiometer to gradually shift the display until the edge of the pulse coincides with a junction formed by the dotted 90 % line and a vertical graticule line. The edge of the pulse must still intersect the dotted 10 % line. Since the vertical line forming the junction with the dotted 90 % line is now the reference point, no readjustment must be made to the X POSITION control
- Check, by means of the delayed time-base TIME/div. switch, that the display has an amplitude of exactly eight divisions before measuring the horizontal distance between the time reference point and the point at which the trace cuts the dotted 90 % line. See Fig. VIII-10.
- Calculate the rise time as detailed in the previous paragraph

6. Phase difference measurements

a. General information

The phase difference between two separately displayed sinusoidal signals may be evaluated with the aid of the PM 3250 oscilloscope.
The following methods may be applied to signals having a frequency of up to 50 MHz, provided that the GAIN switch is set to x1. If the GAIN switch is set to x10, then an accurate result can only be obtained from waveforms of up to 5 MHz.
The main time-base is used for fairly large phase difference measurements, whereas the delayed time-base is best suited to the measurement of small phase differences. In order to assess the total possible error in a phase difference measurement, reference should be made to the introductory paragraphs which explain the various sources of possible error.

b. Phase difference measurements using the main time-base

This method is used to measure large phase differences. If, therefore, a reasonably large separation between the displayed pulses cannot be obtained, the delayed time-base should be used, as detailed in sub para c. If the phase difference between the two displayed pulses appears to be too small, use the MAGN switch to enlarge the display. Proceed as follows:
– Connect the two signals to the Y_A and Y_B input sockets using probes or coaxial cables with identical time delay properties
– Set the AC/0/DC switches to the positions which are best suited to the input signals
– Set the CHOPP/ALT switch to CHOPP for low frequencies, or to ALT for high frequencies

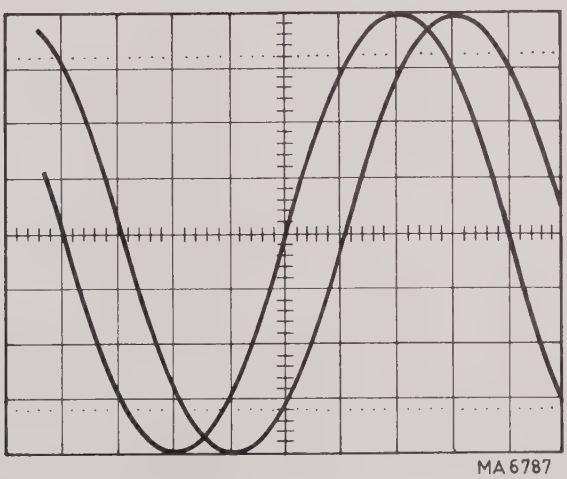

Fig. VIII-13. Main time-base phase difference measurement with leading waveform displayed over exactly eight divisions

– Set the A/OFF/A–B switch to A, and the B/OFF/–B switch to B
– Set the Y_A/Y_B/EXT switch to the channel (Y_A or Y_B) carrying the signal which leads in time
– Adjust the main time-base LEVEL control so that the waveform commences at a suitable point on the graticule
– A 180° phase inversion may be applied to channel B by setting the B/OFF/–B switch to –B. This inversion must be taken into account when the actual phase difference is calculated.
– Using the AMPL switches and their associated potentiometers, adjust both waveforms until they are equal in amplitude. The waveforms should be as large as possible (preferably a full eight vertical divisions) See Fig. VIII-13.
– Correct any instability by using the main time-base triggering controls
– If necessary, use the POSITION controls in order to dispose both waveforms symmetrically about the centre-line

– Set the TIME/div. switch and TIME/div. potentiometer of the channel which carries the leading waveform, in order to display the leading waveform over exactly eight horizontal divisions. In this condition, each division represents $360^{o}/8 = 45^{o}$. If the MAGN switch has been operated, each division will represent only 9^{o}

c. Phase difference measurements using the delayed time-base

This method is used in cases where the phase difference is small.
Set up the display in accordance with the first ten steps of the previous paragraph, then proceed as follows:

– Set both TIME/div. potentiometers to CAL.
– Temporarily switch off the channel which carries the lagging phase and use the appropriate TIME/div. switch to display the leading signal over the largest possible distance, without use of the first and the last division
– Measure the horizontal distance between the zero and 360^{o} points of the leading signal. Determine the period of the leading signal by multiplying the horizontal distance by the deflection coefficient setting of the associated TIME/div. switch
– Set the AFTER DELAY TIME switch to STARTS
– Set the TIME/div. switch of the delayed time-base to a position which produces the smallest possible length of display intensification, shown in Fig. VIII-14. A small readjustment of the INTENS control may prove necessary
– Adjust the DELAY TIME MULTIPLIER, in conjunction with the TIME/div. switch of the delayed time-base, in order to shift the intensified portion to the point at which the two pulses cross the centre-line of the graticule
– Set the MAIN TB/DEL'D TB/EXT switch to DEL'D TB. An enlarged display of the intensified portion will now be presented
– Obtain any possible enlargement of the new display using the delayed time-base TIME/div. switch. It may now be necessary to make a small adjustment to the FOCUS control
– Shift the display by means of the POSITION control, until one of the measuring points is aligned with its nearest vertical graticule line shown in Fig. VIII-15.
– Measure the horizontal distance between the two measuring points which represents the phase difference. Multiply this measured distance by the deflection coefficient setting of the delayed time-base. This result is the time duration between the two edges
– Insert the values obtained into the following formula, where T is the period of one complete cycle, and ΔT is the time duration between pulses:

$$\text{Phase difference} = \frac{\Delta T}{T} \times 360^{o}$$

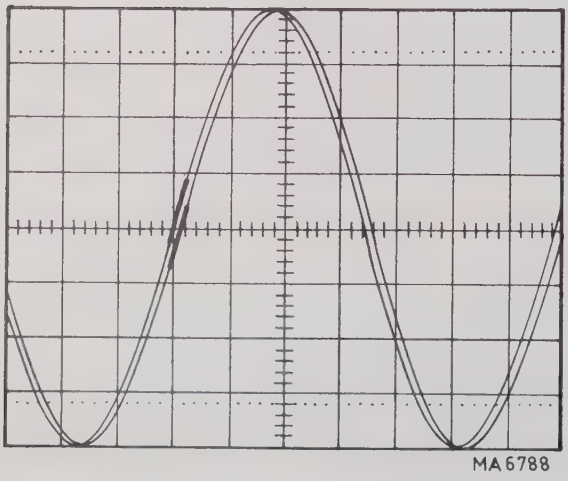

Fig. VIII-14. Phase difference display with the intensified portion located at a point where the two pulses cross the centre-line

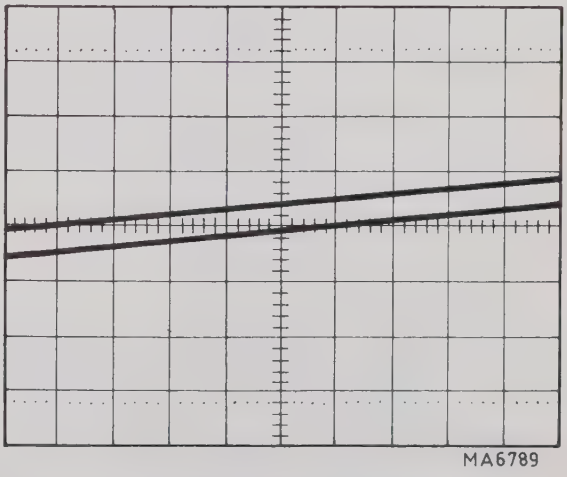

Fig. VIII-15. Enlarged portion of the display with one measuring point shifted to its nearest vertical graticule line

D. X-Y MEASUREMENTS

1. Introduction

When the X DEFL switch is set to EXTERN via Y_B, channel A input provides the Y deflection and channel B input provides the X deflection. The PM 3250 oscilloscope can therefore be used to perform X-Y measurements, so that phase difference and frequency measurements can be performed.

2. Phase difference measurements

When the oscilloscope is operating in the X-Y mode, the input of two sinusoids having identical frequency and phase will result in the display of a line. If there is a phase difference between the two signals, an elliptical display will be obtained. The dimensions of this display can be used to evaluate the phase difference.
Proceed as follows:

- Connect one signal to the Y_A, and the other to the Y_B input
- Use the AMPL switches and potentiometers, in combination with both Y position controls to obtain a symmetric ellipse with both upper and lower ends touching horizontal graticule lines, as indicated in Fig. VIII-16

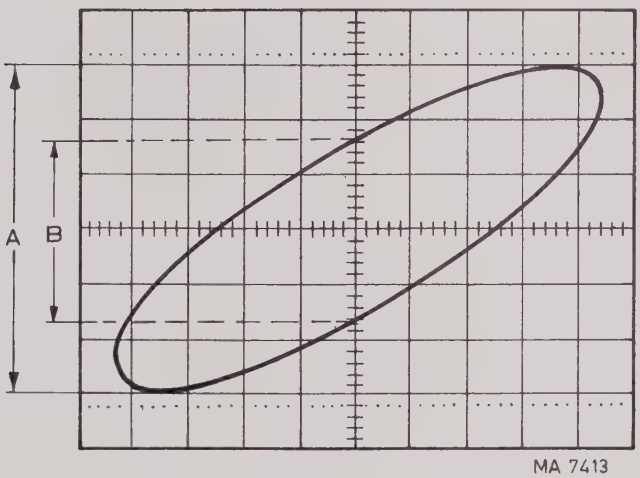

Fig. VIII-16. Phase difference measurement in X-Y mode

- Determine the vertical distance (A) between the upper and lower ends of the ellipse
- Determine the vertical distance (B) between the points where the ellipse crosses the centre vertical graticule line

The sine of the phase difference angle is $\frac{B}{A}$

Reference to trigonometric tables will enable the phase angle to be found.

3. Frequency measurements

Use of a high accuracy sine wave generator in conjunction with the PM 3250 oscilloscope enables unknown frequencies to be measured.
This technique involves the display of Lissajous figures using the generator as a variable reference source.
With the oscilloscope operating in the X-Y mode, the unknown frequency is applied to one input channel and the sine wave generator is connected to the other channel. The sine wave generator can then be adjusted to a frequency at which a stable display of a Lissajous figure is obtained. The reading of the sine wave generator and the shape of the figure can then be used to evaluate the unknown frequency.

E. DIFFERENTIAL MEASUREMENTS

1. Introduction

The difference between two separately displayed signals can be presented by setting the A/OFF/A–B switch to A–B. In this circumstance, the signal connected to channel Y_B is displayed together with the waveform which represents the difference between the two inputs.
If, therefore, the two displayed signals are in common mode (i.e. the signals are constantly equal in potential) then the difference signal will be zero and the resulting display will be a horizontal linear trace.
When a very small a.c. signal is superimposed upon one of two common mode signals, the common mode component of the waveform may be rejected by setting the A/OFF/A–B switch to A–B.

2. Differential measurements

Proceed as follows in order to make a differential measurement:
– Set the AC/0/DC switches to DC
– Connect the two signals to the Y_A and Y_B sockets using probes or cables with identical time delay properties
– Set the AUTO/TRIGG/SINGLE switch to AUTO
– Set both AMPL potentiometers to the CAL position
– Set the two AMPL switches to settings which are equal and which produce the largest possible display within the viewing area
– Set the A/OFF/A–B switch to A–B. The difference in amplitude will now be displayed. This display may be enlarged by stepping both AMPL switches simultaneously, to more sensitive positions.
The channel B display can be removed from the screen by setting the B/OFF/–B switch to OFF.
Alternatively, the channel B display may be inverted by setting the switch to –B.

In some cases, the common mode rejection may be improved by applying a slight adjustment to one of the AMPL potentiometers.

3. Common mode rejection factor

Since common mode rejection is partially dependent upon the amplitude ratio of the two signals under examination, the common mode component of a signal may not always be totally rejected.
It is, therefore, necessary to express the common mode rejection factor of a differential oscilloscope.
This factor is evaluated by dividing the amplitude of two equal common mode input signals by the amplitude shown in the display which they produce, as shown in Fig. VIII-16. Note that a considerable increase in the AMPL setting may be necessary in order to measure the amplitude of the display.

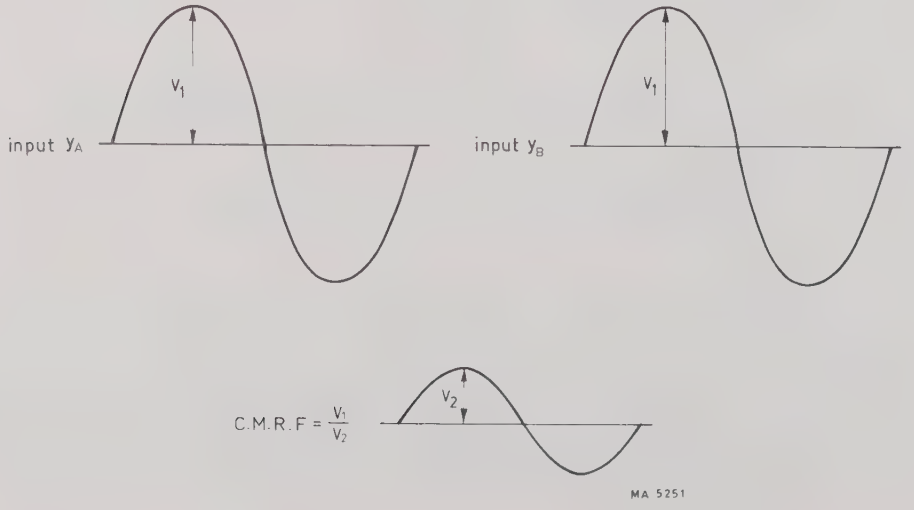

Fig. VIII-17. Determining the common mode rejection factor

F. OSCILLOSCOPE OUTPUT SIGNAL APPLICATIONS

A positive square wave gating pulse output at an amplitude of +2 V is available from DEL'D + GATE socket, whenever the delayed time-base is in operation. This output has the same frequency as the delayed time-base circuit, and the gating pulse width is set by the TIME/div. switch of the delayed time-base.
The DEL'D + GATE output may be used to trigger an external circuit at any predetermined instant after the commencement of the main time-base sweep. The amount of delay is chosen by means of the DELAY TIME MULTIPLIER and main time-base TIME/div. controls.

The gating pulse is used as follows:
- Connect the input signal to the Y_A channel and set the main time-base controls to obtain a stable display
- Set both TIME/div. potentiometers to the CAL position
- Use the DELAY TIME MULTIPLIER to set the delay time which will be the product of the main time-base TIME/div. switching setting and the DELAY TIME MULTIPLIER reading
- Connect the gating pulse output to the external circuit. Triggering will occur at the beginning of the intensified portion provided that the circuit triggers on the positive-going edge of the gating pulse, or at the end of the gating pulse if the circuit triggers on the negative-going edge.

G. PHOTOGRAPHING SCREEN TRACES

Displays may be photographed by means of the camera assembly PM 9380.
Refer to the PM 9380 manual for details.

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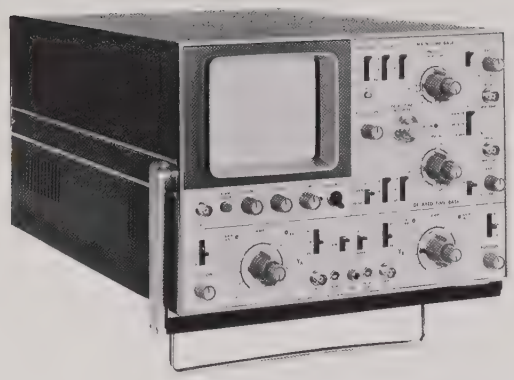

Service manual

Dual-trace oscilloscope PM3250(X)

730416/04

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IX. Circuit description

A. INTRODUCTION

The information contained in this manual applies to the /04 version of the PM 3250 oscilloscope.

B. GENERAL

The PM 3250 oscilloscope comprises a number of units, some of which are further divided into sub-units as shown in the following table:

UNIT No	*DESCRIPTION*
1	Supply unit
2	Supply panel (part of unit 1)
3	Unblanking amplifier (part of unit 1)
4	Chopper panel 1 (part of unit 7)
5	High tension unit (part of unit 7)
6	Chopper panel 2 (part of unit 7)
7	Chopper unit (part of unit 1)
8	Diode panel (part of unit 1)
9	Calibration unit
10	Time-base
11	Delayed time-base (part of unit 10)
12	Main time-base (part of unit 10)
13	Delayed time-base switch (part of unit 10)
14	Main time-base switch
15	Preamplifier A compl.
16	Preamplifier A, panel 1 (part of unit 32)
17	Preamplifier A, panel 2 (part of unit 33)
18	Attenuator A switch (part of unit 15)
19	Preamplifier B compl.
20	Preamplifier B, panel 1 (part of unit 34)
21	Preamplifier B, panel 2 (part of unit 35)
22	Attenuator B switch (part of unit 19)
23	Horizontal output amplifier
24	Vertical output amplifier
25	Trigger pick off stage
26	Electronic switch driver (a) and intermediate amplifier (b)
27	Rear face assembly
28	Front face assembly
29	Potentiometer bracket (part of unit 31)
30	Potentiometer bracket (part of unit 31)
31	Partition plate
32	Preamplifier A, panel 1 (part of unit 15)
33	Preamplifier A, panel 2 (part of unit 15)
34	Preamplifier B, panel 1 (part of unit 19)
35	Preamplifier B, panel 2 (part of unit 19)
36	Drift reduction amplifier
37	Modulator unit (2 pieces fitted on unit 36)
43	Line-Field sync. unit (PM 3250X)

C. VERTICAL AMPLIFIERS

1. Preamplifier with drift reduction

a. Introduction

The following circuit description applies to the preamplifiers of channels A and B. Since these two preamplifiers are identical, only that of channel A is described. The circuit diagram of the channel A preamplifier is shown in Fig. XIV-3 and XIV-4.

b. Input coupling

The AC/0/DC switch SK21 enables the input signal to be either a.c. or d.c. coupled to the input attenuator. When the switch is in the '0' position, the input socket is isolated from the attenuator and the input of the attenuator is connected to earth.
Capacitor C101 is discharged by means of resistor R101 whenever the AC/0/DC switch SK21 is in either the DC or '0' position. This protects the circuit from which the input signal is being taken, from discharges which might otherwise occur when SK21 is transferred to the AC setting.

c. Deflection sensitivity control

The deflection sensitivity attenuator switch (i.e. the AMPL switch SK26) has 13 calibrated settings ranging from 2 mV/div. to 20 V/div.
For deflection coefficients of 2 mV/div., 5 mV/div., and 10 mV/div., the gain of the amplifier is changed.
For the remaining deflection coefficients, frequency-compensated attenuation resistors are inserted into the input circuit. Trimmers, connected into the attenuator circuit, enable a constant value of input capacitance to be set up.
The GAIN switch SK22, which is part of the delay line driver circuit, enables the vertical deflection sensitivity to be increased by a factor of 10. The increase in deflection sensitivity necessitates a corresponding reduction in bandwidth, in order to limit noise. This is effected in the intermediate amplifier, see chapter C.4.

d. Input source follower

A field effect transistor connected in common source configuration, provides a high input impedance, whereas the output from which the next amplifier stage is driven, has a low impedance.
Two diodes (GR101 and GR102) are provided as safeguard against too high input voltages.

e. Preamplifier stages with feedback

The preamplifier which follows the input source follower consists of two stages of amplification. Each stage comprise transistor pairs with shunt and series feedback. The transistors contained in the first and second stage respectively are TS102-103-106-108 and TS107-109-111-112.
For deflection coefficients of up to 20 mV/div., the AMPL switch is used to adapt the gain of the amplifier by inserting different values of resistance into the emitter circuits of transistors TS107 and TS109. The remaining deflection coefficients are obtained by using SK26 to select a frequency-compensated input attenuator circuit.
Reference to the following paragraph dealing with drift compensation will show that the 1/A attenuator must be altered to suit a selected gain. This alteration is made by means of resistors R129 and R131 which are switched into circuit at the settings of the AMPL switch SK26 (i.e. at deflection coefficients of 2, 5 or 10 mV/div.).
When deflection coefficients of 20 mV/div. or more are selected, the gain of the amplifier is fixed at an exact value which suits the 1/A attenuator, by means of potentiometer R122. Correct operation of the drift compensation system is dependent upon accurate gain setting.

In the most sensitive setting of the AMPL switch, the amplifier gain is determined by R143, and by other fixed resistors in the 5 mV/div. and 10 mV/div. positions.
The signal and its associated trigger signal are taken asymmetrically from the AMPL. continuous control potentiometer R14 and from the emittor of TS113 respectively.
Overall gain of the vertical amplifier may be adjusted by means of the GAIN ADJ potentiometer R10 which is accessible via a hole in the front plate.
Optimum frequency and step response are obtained by the feedback loops and RC networks in the emitters of the amplifier circuit stages.

f. Drift compensation

A drift compensation circuit, the main section of which is an extremely low-drift chopper amplifier, has been incorporated in each vertical amplifier. A detailed description of the chopper amplifier circuit for channel A is given in section **g**. The chopper amplifier for channel B is identical to that of channel A.
Assume that $-A$ is the gain of the vertical amplifier whose drift is being compensated for.

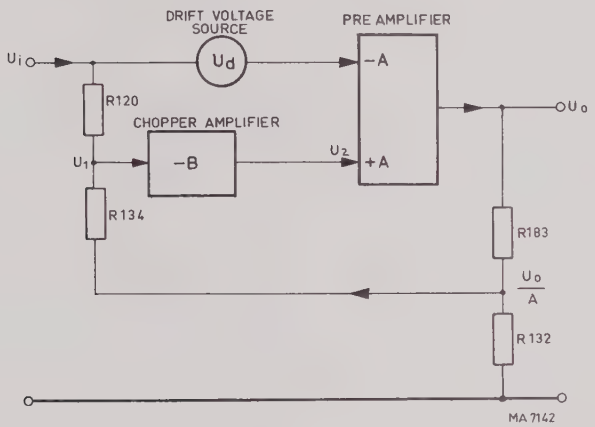


Fig. IX-1. Simplified diagram drift reduction circuit

The drift voltages in the vertical amplifier are referred to the input, and are assumed to originate from an imaginary voltage source U_d. The input voltage is U_i so that the output voltage before drift compensation, can be expressed as $-A\ (U_i + U_d) = U_{o1}$.
A voltage divider (R183 and R132) attenuates the output voltage of the vertical amplifier by a factor of A, hence the voltage divider output may be expressed as $\frac{U_o}{A}$. This quantity $\frac{U_o}{A}$ is added to the input voltage U_i by means of two high-value resistors R134 and R120.
The resulting output U_1 is applied to the drift compensation amplifier (chopper amplifier) which has a gain of $-B$. The output of this amplifier, U_2, is fed to the vertical amplifier as a correction signal.
The system is shown schematically in Fig. IX-1, and it can be seen that:

$$U_{o2} = -A\left(U_i + \frac{U_d}{1 + \frac{B}{2}}\right)$$

This formula can be used to show that after drift correction, the output voltage U_{o2} contains $\frac{1}{1 + \frac{B}{2}}$ less drift voltage than U_{o1}.
When, therefore, the gain of the chopper amplifier ($-B$) is high, drift can be neglected.
Capacitor C116 is connected into the drift compensation circuit when the AC/0/DC switch is set to AC. When a signal with a high d.c. component is applied to the circuit, a considerable d.c. component will be present at the input of the amplifier; to compensate for this, C116 is introduced so that the d.c. level is kept at zero by the chopper amplifier.

g. Chopper amplifier

The drift compensation chopper amplifier modulates its input signal using a square-wave signal (approx. 1700 Hz). After amplification, the signal is demodulated so that the phase relationship is maintained. This demodulated output, which is the amplified drift signal, is applied to the vertical amplifier.
The modulator section of the circuit is formed by by two m.o.s. field effect transistors (TS1408 and TS1410) which are alternately driven. To avoid any influence from humidity the modulator section has been moulded in a nine pin encapsulation.
The modulated signal is amplified (approx. 4000 χ) by an integrated operational amplifier (IC1401).

The amplified signal is applied to the demodulator which consists of a pair of m.o.s. field effect transistors (TS1401 and TS1402) which are alternately driven by the above mentioned square-wave signal.
The astable multivibrator TS1409 and TS1411 acts as the driver for the modulator as well as the demodulator. In addition, the multivibrator also provides driving signals for the chopper amplifier of channel B. Capacitor C1403 counteracts spikes on the signal which are caused by differences in circuit and transistor capacitance.
The offset voltage is compensated by means of potentiometer R1406.
The output d.c. voltage of the drift reduction amplifier is connected together with a d.c. voltage from the d.c. balance pot. meter (at front panel) to the anti-phase input transistor (TS104) of the preamplifier.

2. Intermediate amplifier

In the intermediate amplifier circuit diodes GR1601, GR1602, GR1603, and GR1607 perform the switching operations in the mode selection circuitry.
When the A/OFF/A–B switch SK20 is set to A, a negative 12 V supply is connected to R1605: diodes GR1602 and GR1607 therefore conduct. The circuit input is then formed by TS1601 and TS1604 so that the A channel signal is connected to the intermediate amplifier.
At the same time, resistor R1608 is positive so that diodes GR1601 and GR1603 are switched off causing transistor TS1603 to cut off.
To eliminate the crosstalk which might otherwise be introduced via TS1603, diode GR1605 is cut off and GR1606 is switched on. Any unwanted signals are thus isolated from the remainder of the circuit.

Setting the A/OFF/A–B switch to A–B results in a negative 12 V supply being connected to R1608.
This makes transistor TS1602 conduct so that diodes GR1601 and GR1603 also conduct.
The negative supply to R1605 is interrupted and diodes GR1602 and GR1607 are cut off. At the same time, diodes GR1605 and GR1606 change states so that TS1603 is fully operational as the channel B input of a differential amplifier.
Sensitivity change involved in switching between the A and A–B modes of operation may be eliminated by selection of R1615 which is in parallel with R1614. The tendency towards a change in sensitivity whilst switching between the A and A–B modes, is due to the rather large value of base resistor for TS1604 (which is in common base configuration). The overall emitter resistance of this transistor is significantly increased by the resistance present in the base circuit.
When the A/OFF/A–B switch is set to OFF, transistor TS1601 is functioning (via GR1602) but the A channel signal is blocked in the electronic switch.
Switch B/OFF/–B SK25 controls directly the electronic switch in the B channel part of the intermediate amplifier.

3. Electronic switch and switch driver

An electronic switch is used to control the gating circuitry which gates the intermediate amplifier outputs to the delay line driver.
The electronic switch is also used to transfer channel B signal to the horizontal amplifier when the oscilloscope is used for X-Y displays.
The electronic switch signals originate from a multivibrator which is formed by transistors TS512 and TS513. This multivibrator is driven by a blocking oscillator (TS517) that is free-running provided switch SK23 is set to the CHOPP.-position and both channels are in operation. When SK23 is set to ALT, relay RE503 is energized and trigger pulses are applied to the blocking oscillator by the closed contacts of this relay. Channels A and B may then be displayed alternately since the trigger pulses (which are obtained from the main time base via the amplifier formed by TS518 and TS519) are a replica of the unblanking pulses.
There are two other conditions which cause relay RE503 to supply trigger pulses to the blocking oscillator, i.e.:

1. One or both channels switches set to OFF
2. X DEFL switch set to EXTERN via Y_B

In these two particular conditions the multivibrator is kept stable.
Application of the trigger pulses then serves only to prevent spikes which might otherwise occur on the display should the blocking oscillator be free-running. Hence, the free-running condition is only obtained when the switch SK23 is set to CHOPP. and both channels are in operation. In all other conditions the blocking oscillator is driven by the trigger pulses, irrespective of whether or not the multivibrator is being switched. When both channels are in operation, the two driver signals which are opposite in polarity and which are obtained from the multivibrator, are applied to:

1. the base of transistor TS407 in order to control channel A output to the delay line driver, and
2. the bases of transistors TS412 and TS414 in order to control channel B outputs to the delay line driver

The transistors enumerated in 1 and 2 above, switch associated gating circuits (formed by GR401, GR402, GR403, and GR404 for channel A, and GR416, GR417, GR418, and GR419 for channel B) which transfer the display signals to the delay line driver, or to the horizontal amplifier.
If the A/OFF/A–B switch is set to its OFF position, a negative 12 V supply is connected to diode GR503 and the collector of TS512 becomes positive. Transistor TS513 then conducts and the multivibrator is held in this state (i.e. TS513 conducting and TS512 not conducting) until a further channel switching operation is made. The electronic switch is therefore set in the condition which causes TS407 to switch on diodes GR402 and GR403. Channel A is therefore blocked. As previously described, RE503 is energized by a negative supply obtained via diode GR518 and SK20. The blocking oscillator runs due to the trigger pulse train, although the multivibrator is not driven. The state of the multivibrator is reversed by setting the B/OFF/–B switch to OFF whilst the A/OFF/A–B switch is set to either A or A–B. In this circumstance the input to the horizontal amplifier is totally blocked due to the conduction of diodes GR1155 and GR1157. Relay RE503 is energized via GR517.
In addition to this, both channels may be simultaneously blocked by setting both channel control switches to OFF. The intermediate amplifier output is normally isolated from the horizontal amplifier due to the conduction of diodes GR1152 and GR1153 as well as the non-conduction of GR1151 and GR1154 (also by the non-conduction of GR1155 and GR1157 if the B/OFF/–B switch is set to OFF).
However, if the X DEFL switch is set to EXTERN via Y_B diodes GR1151 and GR1154 are made to conduct and GR1152 and GR1153 are switched off by means of a positive potential which is applied via the closed contacts of switch SK10. In addition to this, transistor TS514 conducts so that TS513 is switched off. Transistors TS412 and TS414 therefore conduct and diodes GR417 and GR418 open whilst GR416 and GR419 cut off. The various diode states now provide a condition in which the channel B input to the delay line driver is blocked and the horizontal amplifier is opened to accept signals from channel B.
When the GAIN switch SK22 is set to its x10 position, +24 V is connected, via resistor R576, to the junction of GR519 and C528. This results in GR519 conducting, since its cathode is at a potential of +12 V, and so the capacitor C528 shunts C524. The blocking oscillator frequency is consequently reduced from 1 MHz to approximately 200 kHz and an improvement in circuit operation is obtained.

4. Delay line and delay line driver

Outputs taken from the electronic switch are applied to a three stage delay line driver prior to being applied to the 65 ns delay line L603.
The first stage of the delay line driver is formed by transistors TS417 and TS419. Shunt feedback is provided by means of transistors TS416 and TS418.
The second stage consists of TS421 and TS423 which are controlled by the GAIN and BEAMFINDER switches. With GAIN switch (SK22) in the x1 position the +24 V supply is connected to R446 via GR425, and the collector load of TS421 and TS423 consists of R448 and R453 (in parallel to R437 and R443) because GR426 and GR427 are conducting via R460.
In the x10 position of the GAIN switch, the collector load of TS421 and TS423 is increased, because +24 V is connected to R449, so that GR426 and GR427 are blocked. At the same time the emittor current of TS421 and TS423 is decreased because +24 V is now fed to the emittors via R425.
By the increase of the collector load also upper bandwidth limitation (to approx. 5 MHz) is obtained.
The third stage of the delay line driver formed by transistors TS422 and TS424 provides compensation for the signal loss incurred in the delay line.

5. Vertical output amplifier

The signal obtained from the delay line is applied to the vertical output amplifier which consists of three stages. The first stage is formed by TS602 and TS603, with TS601 and TS604 providing feedback.
Transistors TS606 and TS607 are connected as an intermediate stage with series feedback.
The third stage is a single-ended push pull output circuit with shunt feedback which is formed by transistors TS608, TS609, TS611, and TS612. Adjustment of driving range symmetry is by means of potentiometers R632, R633, R638, R642 and R643.

D. TRIGGER PICK-OFF STAGE

The trigger pick-off stage is arranged as two separate circuits, one for channel A and the other for channel B. The circuit for channel A is also used to produce an A-B trigger signal when the oscilloscope is operating in the differential mode.

Signals from preamplifiers A and B are connected to the respective trigger pick-off circuits in order to drive the main and delayed time-bases.
The signal from preamplifier A is applied to the base of transistor TS501 which is in emitter follower configuration. The base of the second emitter follower (TS504) is connected to earth via the closed contacts of relay RE501 provided that the oscilloscope is not operating in the differential mode. With the A/OFF/A–B switch SK20 set to A, the channel A signal passes via TS501, to the amplifier stage which is formed by TS502 and TS506. This amplifier stage produces two identical outputs; one for the main time-base and the other for the delayed time-base.
The signal from preamplifier B is connected, via emitter follower TS507, to the amplifier is formed by TS508 and TS511. Two identical outputs are produced (one for each time-base).
If the A/OFF/A–B switch SK20 is set to A–B, relays RE501 and RE502 changeover. This causes the earth connection to be removed from TS504 due to the open contacts of RE502. At the same time, closure of RE501 contacts applies the signal of channel B to the base of emitter follower TS504. The amplifier formed by TS502 and TS506 then acts as a difference amplifier, so that the resulting trigger outputs to both time-base are an A–B function.
When the GAIN switch SK22 is set to x10, additional resistance is inserted into the emitter circuits of both trigger pick-off amplifiers (consequently amplification is increased by 10).
Transistor TS503 is connected as a current source which provides a high common mode rejection factor during the formation of differential trigger signals.

E. MAIN AND DELAYED TIME-BASES

1. Main time-base

a. Introduction

The trigger signals derived from the trigger pick-off stage (U25) are applied to the main time-base trigger amplifiers which are located on unit 12. An additional input circuit on unit 12 is for external trigger source signals which are connected to the oscilloscope via the main time-base TRIGG. socket BU1.
The selected trigger signal (channel A, channel B, or external) is applied via the coupling switch SK2 to the pulse shaping circuits of the main time-base.

b. Trigger amplifiers

The following circuit description applies to the trigger amplifiers of channel A and channel B. Since these two amplifier circuits are identical, only that of channel A is described.
The channel A trigger signal (or the A–B signal when the oscilloscope is operating in the differential mode) taken from the trigger pick-off stage is applied to the base of transistor TS901. The emitter potential of this transistor is held constant by TS902, and its base bias is set by the preset potentiometer R901. The output of this trigger amplifier is connected to the contacts of the trigger source switch SK2.
External trigger signals connected to the oscilloscope via the main time-base TRIGG socket BU1 are passed to two emitter followers (TS906 and TS907).
The network which couples BU1 to the two emitter followers includes a capacitor C907 which is shorted if the coupling switch SK3 is set to DC. The network presents a constant input impedance of 1 MΩ in parallel with 20 pF, and affords protection against high input voltages.

c. Trigger multivibrator

The particular trigger signal to be used to drive the trigger multivibrator is selected by means of the source switch SK2. The trigger signal is then passed to the base of transistor TS908 by means of the coupling switch SK3. With this switch set to DC, the coupling is direct so that there is no bandwidth limitation.
In the LF setting of SK3 the signal is coupled via C909, C911 and the low pass filter which consists of R938 and C913. This filter bypasses those frequencies above approximately 1 MHz and below 3 Hz.
With SK3 at HF, coupling is via C912 which blocks those frequencies below approximately 2 kHz.
TS908 is an emitter follower whose output is connected via diode GR901, to the slope switch SK4. A second emitter follower (TS909) is controlled by the LEVEL potentiometer R1 in order to set a d.c. level which is also connected to the contacts of the slope switch SK4. The LEVEL control range may be extended by a factor of 5 by operation of the 'PULL FOR x5' switch SK5, which causes R942 to be connected in parallel with R943. The d.c. level obtained from TS909 is used to determine the exact point at which the multivibrator is triggered.

The outputs obtained from emitter followers TS908 and TS909 provide inputs to the difference amplifier formed by TS911 and TS914. The inputs to this difference amplifier may be changed over by operation of switch SK4 and this facility enables triggering to be effected on either the positive-going or negative-going edge of the input signal. The amplitude of the input signal is limited by diodes GR903 and GR904, which are connected in anti-parallel across the input contacts of switch SK4. The resulting signals on the collectors of TS911 and TS914 are opposite in polarity, and are applied to the trigger multivibrator (Schmitt-trigger) which is formed by transistors TS912 and TS913. When driven by the difference amplifier, the trigger multivibrator produces a square wave output of constant amplitude, whose relationship to the trigger input is determined by the LEVEL potentiometer R1.

d. Differentiator stage

The constant amplitude square wave output taken from the trigger multivibrator output transistor TS913 is applied to the differentiator stage which comprises C915, TS916 and TS917.
The positive-going edges of the input signal are differentiated by means of transistor TS916 and are used to control the auto circuit (see para j). Differentiation of the negative-going edges is effected by transistor TS917, whose output forms part of the waveform which drives the sweep gating multivibrator.

e. Sweep gating multivibrator

The sweep gating multivibrator is formed by transistors TS922 and TS923 which are connected as a Schmitt-trigger, the base of TS923 being the input terminal.
The output of this circuit is connected to transistors TS934 and TS935 of the integrator circuit. These transistors are used to obtain rapid fly-back of the time base sawtooth voltage (see para f).
If the sweep gating multivibrator output is at its minimum positive level, transistor TS934 of the integrator circuit is cut off. The particular time capacitor connected into the circuit by means of the TIME/div switch SK7 is therefore charged by a linearily-increasing voltage and a main sweep is initiated.
This condition of the multivibrator (i.e. output at minimum positive level, causing a main sweep) is termed the 'set' condition.
With the sweep gating multivibrator in its other condition (output at maximum positive level) the time capacitor connected via switch SK7 is totally discharged due to TS934 and TS935. No sweep is therefore generated and this state of the sweep gating multivibrator is termed the 'reset' condition.
Assuming the Schmitt-trigger to be in the reset condition, the input signal must fall to a given switching level in order to change the Schmitt-trigger to its 'set' state. Subsequent excursions of the input to this given switching level will not affect the Schmitt-trigger. However, if the input signal rises to another given switching level the Schmitt-trigger will reset. The Schmitt-trigger will then not revert to its 'set' state until the input voltage again falls to the 'set' switching level.
The two (set and reset) switching levels are disposed about a nominal +3 V level known as the 'set ready' level. The potential between the 'set' and 'reset' levels is termed hysteresis.
The sweep gating multivibrator control waveforms are developed by various combinations of the following four sources:

- The trigger pulse train obtained from the transistor TS917
- The d.c. level determined by the stabilization potentiometer R1036 and applied by transistor TS927.
- The auto circuit output applied via TS927.
- The hold-off circuit output, also applied via TS927.

The particular number of the above-listed waveforms which are summed in order to produce the required input signal for the sweep gating multivibrator is determined by the setting of the AUTO/TRIGG/SINGLE switch SK1.

Note: The relationship between the various waveforms which control the sweep gating multivibrator is somewhat complex. The circuits from which the waveforms originate are therefore discussed prior to a detailed description of the sweep gating multivibrator control functions, given in para k (operation of the main time-base).

f. Integrator circuit

The integrator circuit is a section of the main time-base in which a linearly-increasing voltage is developed by means of the two voltage regulation transistors TS936 and TS941. These transistors cause a constant current to be passed through the particular resistor which has been selected by the setting of the TIME/div. switch SK7. The exact value of the current which passes through the selected resistor depends upon the voltages obtained from transistors TS936 and TS941 and upon the value of the selected resistor.

The voltage derived from transistor TS941 (and consequently the current through the selected resistor) is normally constant unless the TIME/div. control is moved from its CAL position.
In this circumstance, the switch SK8 is opened and potentiometer R2 of the TIME/div. control may be used to adjust the voltage supplied by TS941.
The base bias of TS936 is set by means of potentiometers R1049 and R1052 which are each connected between the +24 V line and earth. These potentiometers therefore provide an accurate means by which the current flowing through the selected resistor may be adjusted.
The current flow developed by means of TS936 and TS941 is used to charge a time capacitor which is also selected by the TIME/div. switch.
Since the current source maintains a constant value, the voltage across the capacitor remains a linear increase throughout the charging period. The farther the TIME/div. potentiometer control is advanced from its CAL position, the lower becomes the rate of voltage increase across the capacitor.
Immediately the voltage across the selected time capacitor attains a given value, the hold-off circuit provides a level which is applied to the sweep gating multivibrator via transistor TS927. This causes the sweep gating multivibrator to change to its 'reset' state, i.e. the output at the collector of TS922 is raised to its maximum positive level. Transistor TS935 switches hard on, and this causes the capacitor to rapidly discharge. At the same time the current from TS936 is short-circuited to mass by TS934. It can therefore be seen that a saw-tooth waveform is developed across the time capacitor.
A further sawtooth sweep will be generated when the sweep gating multivibrator changes to its 'set' condition. The sweep waveform taken from the capacitor is applied to the base of the emitter follower TS937, the output of which is fed to the base of TS938.
The main sweep waveform present at the emitter of TS938 is fed to the following points:
– To the output socket BU11 by way of transistor TS951
– To the comparator circuit in order to initiate the delayed sweep (if required)
– To the hold-off circuit in order to effect the ultimate discharge of the integrator capacitor upon completion to a sweep

The main sweep waveform is also connected to the horizontal output amplifier, provided that the MAIN TB/DEL'D TB/EXTERN switch SK10 is set to MAIN TB.
The 23 position MAIN TIME BASE TIME/div. switch SK7 provides a total of 23 calibrated deflection coefficients ranging from 1 s/div. to 0,05 μs/div. The following table lists the components chosen for each of the 23 TIME/div. settings:

Components selected by the TIME/div. switch SK7

TIME/div. setting	*Main time-base capacitor between points A and B*	*Resistor between G and C*	*Hold off capacitor between points A and H*	*Connection (DE or DF)*
1 s/div.	C871	R871 + R877	C877	DF
0.5	C871	R876	C877	DF
0.2	C871	R874	C877	DF
0.1	C871	R873	C877	DF
50 ms/div.	C871	R872	C877	DF
20	C871	R884	C877	DF
10	C871	R883	C877	DF
5	C871	R882	C877	DF
2	C876	R874	C882	DE
1	C876	R873	C882	DE
0.5	C876	R872	C882	DE
0.2	C876	R884	C882	DE
0.1	C876	R883	C882	DE
50 μs/div.	C876	R882	C882	DE
20	C874	R884	C881	DE
10	C874	R883	C881	DE
5	C874	R882	C881	DE
2	C873//C885	R884	C879	DE
1	C873//C875	R883	C879	DE
0.5	C873//C875	R882	C879	DE
0.2	C872	R881	C878	DE
0.1	C872	C879	C878	DE
0.05	C872	R878	C878	DE

g. Hold-off circuit

The output waveform obtained from the integrator circuit is connected to the hold-off circuit via diode GR908. This diode only passes that portion of the waveform which is above the level of the bias potential present at its cathode.
The signal passed by GR908 is applied to the base of transistor TS928 which is connected as an emitter follower whose emitter circuit includes the hold-off capacitor. The particular value of this capacitor is determined by means of the TIME/div. switch SK7 (see points H and A on the main time-base circuit diagram, Fig. XIV-11).
The potential at the emitter of TS928 is used to control the Schmitt-trigger multivibrator formed by TS924 and TS929. In order to clarify the following description, the hold-off multivibrator states are defined as follows.
– High positive output (i.e. the condition which disables the integrator) is termed the 'reset' condition
– Low positive output (i.e. the output which enables the integrator) is termed the 'set' condition

A low input level at the base of emitter follower results in a low output at the collector of the multivibrator transistor TS924 (i.e. the multivibrator is set).
The hold-off multivibrator is powered by means of a current source circuit (transistor TS931) which is part of the single sweep stage.

If the input to the base of transistor TS928 rises above the emitter potential, the transistor will conduct. The emitter voltage of this transistor therefore rises and the hold-off capacitor is charged.
When the base potential falls to the level at which conduction ceases, the emitter voltage of TS928 is held to the potential across the hold-off capacitor. This capacitor discharges through resistor R1029 and this causes the trailing edge of each pulse at the emitter of TS928 to be considerably lengthened.
The trailing edge of each pulse present at the emitter of TS928 is therefore longer than the integrator pulse from which it is originated.

With the oscilloscope operating in the automatic or trigger mode (switch SK1 set to AUTO or to TRIGG) the base potential at TS928 will fall at the same rate as the integrator output waveform: the level to which it may fall is set by the potential divider formed by resistors R1032 and R1033 which are connected in series between earth and a –24 V supply, via switch SK1. In all cases, the leading edges obtained from the integrator will have a sufficiently high level to produce a 'reset' potential at the base (and hence the emitter) of TS928.
When the level of the input signal from the integrator falls to the 'set' level, the hold-off capacitor has the effect of lengthening the trailing edge of the pulse, as previously described. The appearance of the 'set' level at the emitter of TS928 is therefore delayed by a time which is determined by the value of the selected hold-off capacitor. When the hold-off multivibrator is eventually transferred to its 'set' state, the sweep gating multivibrator is provided with a 'set ready' condition via transistor TS927.
The time during which the hold-off multivibrator is its 'reset' condition is termed the hold-off condition. In this condition the integrator circuit cannot be driven. Hold-off time is dependent upon the value of the hold-off capacitor and is always slightly longer than trailing edge of the integrator pulse. This delay allows the integrator circuit to return to its initial state, and correct shaping of the subsequent waveform is ensured.

h. Reset circuit

If the AUTO/TRIGG/SINGLE switch SK1 is set to SINGLE, the –24 V bias supply is disconnected from the cathode of diode GR908 in the hold-off circuit. The bias at the base of TS928 is therefore raised slightly, and the emitter voltage is thus prevented from falling below its 'set' level. In this circumstance, the reset circuit must be used in order to trigger the hold-off multivibrator to its 'set' state.
Operation of the reset circuit SET READY switch SK6 results in an earth connection being applied to the bias network of TS931 which is the current source for the hold-off multivibrator. This blocks the current supply to the hold-off multivibrator so that a 'set' state is produced.
The low positive output gives a 'set ready' condition to the sweep gating multivibrator by means of transistor TS927. With the circuit in this condition, the sweep gating multivibrator will be switched by the first superimposed trigger pulse to be generated by the differentiator.

The integrator is consequently made to produce one pulse. This pulse causes the hold-off circuit to reset.
The high bias voltage at the base of TS928 prevents a consequent setting of the hold-off multivibrator.
The circuit will not therefore be operable after the completion of the single triggered sweep.
A further single sweep can be displayed only after the SET READY switch SK6 is operated.
Visual indication of the oscilloscope being in the single sweep set ready condition is provided by lamp LA3 which is incorporated in the SET READY switch button. When the AUTO/TRIGG/SINGLE switch SK1 is set to its SINGLE position, lamp LA3 is connected to the collector of transistor TS926.

Provided that the hold-off multivibrator is ready to receive a reset pulse (collector of TS929 positive) TS926 will conduct causing LA3 to be illuminated. Immediately the single sweep has taken place, the low positive potential at the collector of TS929 (hold-off multivibrator) causes TS926 to be cut off so that LA3 is extinguished.

i. External triggering

With the X DEFL switch SK10 is set to EXTERN via Y_B, the current source transistor TS931 is cut off due to earth connection which is then applied. This causes the hold-off multivibrator to be reset (i.e. a high positive output at the collector of TS924). The high level output at the collector of TS924 is fed via TS927 to the sweep gating multivibrator, whose condition will then maintain TS934 in a conductive state. The time capacitor connected into the circuit by means of the TIME/div. switch SK7 therefore remains discharged, and no integrated pulses can be produced. Reference to Fig. XIV-13 will show that the integrator is not connected to the horizontal output amplifier whilst the X DEFL switch is set to EXTERN via Y_B.

j. Auto circuit

When the AUTO/TRIGG/SINGLE switch SK1 is set to AUTO, one of two possible levels of d.c. bias is applied to the cathode of diode GR909. The d.c. level is passed to the base of transistor TS927 and therefore influences the sweep gating multivibrator control waveform.
The lower d.c. level causes the hold-off circuit to drive the sweep gating multivibrator in order to develop a trace in the absence of an input signal to the oscilloscope. The high level is produced when an input signal causes the differentiator to operate, positive trigger spikes are than passed to transistor TS918.
The high level has no effect upon TS927 so that oscilloscope continues to function as if it were in the trigger mode. This high level is caused initially by a positive spike from TS916 of the differentiator circuit.
After being inverted by transistor TS918, the pulse is used to switch on TS919 and there is a resultant voltage drop developed across the potential divider formed by R983 and R986. The voltage across R986 causes TS921 to conduct so that current flows through resistors R981 and R982. The voltage across R981 maintains TS919 in its conductive state after the decay of the input pulse from the differentiator.
With both TS919 and TS921 in a state of conduction, the circuit prevents a low impedance which enables capacitor C924 to be discharged.
When C924 is discharged, the current via R988 is too low to maintain TS919 and TS921 in the conductive state. Provided there is a continued supply of trigger pulses from the differentiator, C924 cannot be charged, so that TS927 is biased in such a way that the input of the sweep gating multivibrator only is activated by trigger pulses (via TS917).
If the differentiator circuit is not being driven, no positive spikes will be received from the differentiator. Transistors TS919 and TS921 are therefore cut off and capacitor C924 is charged via R988.
The base potential of TS927 is consequently lowered and this causes the hold off-circuit output waveform being shifted to a level at which it will drive the sweep gating multivibrator.

k. Operation of the main time-base

Triggering

When a suitable input signal is applied to channel A or channel B of the oscilloscope, trigger signals are produced by the trigger pick-off stage. The particular trigger signal (channel A, channel B, or external) used to drive the main time-base is selected by means of the YA/YB/EXT source switch SK2. When the oscilloscope is operating in the differential mode, the trigger signal obtained from channel A is the difference signal.
Trigger signals applied to the trigger multivibrator of the main time-base are compared to a d.c. level which is determined by the LEVEL potentiometer R1, so that the display may be started from any point on the waveform.
Switch SK4 may be used to invert the polarity of the trigger signal, and this facility enables triggering on both the positive-going and negative-going edges of the input signal.

Auto circuit

Trigger signals cause a constant amplitude square wave output to be produced by the trigger multivibrator. This square wave output is passed to the differentiator. The resulting positive-going spikes are applied to the auto circuit in order to prevent the hold-off circuit from driving the sweep gating multivibrator. Note that the auto circuit is inoperative if the AUTO/TRIGG/SINGLE switch is at its TRIGG or SINGLE setting.

Sweep gating multivibrator control

The negative-going spikes obtained from the differentiator are superimposed upon the hold off waveform in order to form the sweep gating multivibrator control signal. This control signal has a d.c. level such that only those trigger spikes which are superimposed upon the lower level of the hold off waveform (termed the 'set ready' level) can influence the sweep gating multivibrator.
When a negative-going trigger spike exceeds the lower switching level, the sweep gating multivibrator will be switched to its 'set' state and a main sweep is initiated in the integrator circuit. Subsequent trigger spikes will not affect the formation of the main sweep. At a predetermined amplitude of sweep voltage, the main sweep is terminated by the action of the hold-off circuit and a hold-off period is initiated, a further sweep cannot then be started by a trigger spike until the hold-off waveform has returned to its 'set ready' level.
If the auto circuit is in operation whilst no input signals are present in the oscilloscope, the level of the hold-off circuit output is reduced to such an extent that it traverses both the 'set' and 'reset' input levels of the sweep gating multivibrator. The sweep gating multivibrator (and hence the integrator circuit) becomes free running due to the drive provided by the hold-off circuit. The resulting sweep waveform produces a horizontal trace on the screen. Immediately trigger signals are present, the auto circuit ceases to have any effect upon the hold-off circuit output.

Single sweep displays

When the oscilloscope is operating in the single sweep mode (switch SK1 set to SINGLE) the lower level of the hold-off multivibrator input waveform is raised above the lower hysteresis level due to the removal of the −24 V bias supply from the base of TS928. Pressing the 'SET READY' button then causes the hold-off multivibrator to be blocked and its output is therefore raised. The sweep gating multivibrator output is therefore held above the hysteresis gap.
Transistors TS934 and TS935 of the integrator circuit are saturated so that the time capacitor is not charged. Release of the 'SET READY' button results in the sweep gating multivibrator input waveform being lowered to the 'set ready' level. If the sweep gating multivibrator is then switched by a negative trigger pulse, a main sweep is initiated.
The hold-off multivibrator is switched over when the sweep voltage exceeds a predetermined potential. The main sweep is then terminated.
The hold-off circuit input waveform is prevented from falling below the hysteresis gap, and the sweep gating multivibrator input level is consequently held at its higher level. A subsequent sweep cannot therefore be initiated.

2. Delayed time-base

a. Introduction

The trigger signals derived from the trigger pick-off stage (U25) are applied to the delayed time-base trigger amplifiers which are located on unit 11. An additional circuit on unit 11 is for trigger source signals which are connected to the oscilloscope via the delayed time-base TRIGG socket BU2. The selected trigger signal (channel A, channel B, or external) is applied via the coupling switch SK2, to the pulse shaping circuits of the delayed time-base.

b. Trigger amplifiers

The following circuit description applies to the trigger amplifiers of channel A and channel B. Since these two amplifiers are identical, only that of channel A is described.
The channel A signal (or the A−B signal if the oscilloscope is operating in the differential mode) taken from the trigger pick-off stage is applied to the base of transistor TS701. The emitter potential of this transistor is held constant by TS702, and its base bias is set by preset potentiometer R701. The output of this trigger amplifier is connected to the contacts of the delayed time-base trigger source switch SK16.
External trigger signals connected to the oscilloscope by way of the delayed time-base TRIGG socket BU2 are passed to two emitter followers (TS706 and TS707). The network which couples BU2 to the base of TS706 includes capacitor C708 which is shorted if the coupling switch SK3 is set to DC.
The network presents a constant input impedance of 1 MΩ in parallel with 20 pF, and affords protection against high input voltages.

c. Trigger multivibrator

The particular signal to be used to drive the trigger multivibrator of the delayed time-base is selected by means of the source switch SK16. The trigger signal is then passed to the base of transistor TS708 by means of the delayed time-base coupling switch SK17. With this switch set to DC, the coupling is direct, so that there is no bandwidth limitation. In the LF setting of SK17 the signal is coupled via capacitors C709 and C710, and the low-pass filter which consists of R738 and C712. This filter bypasses those frequencies above approximately 1 MHz and below 3 Hz. With SK17 at HF, coupling is via C711 which blocks frequencies which are below approximately 2 kHz.
TS708 is an emitter follower whose output is connected to the delayed time-base slope switch SK18.
A second emitter follower (TS709) is controlled by the delayed time-base LEVEL potentiometer R9 in order to set a d.c. level which is also connected to the contacts of the slope switch SK18. The LEVEL potentiometer control range may be extended by a factor of 5 by operation of the delayed time-base 'PULL FOR x5' switch SK19, which causes R742 to be connected in parallel with R743. The d.c. level obtained from TS709 is used to determine the exact point at which the multivibrator is triggered.

The outputs obtained from the emitter followers TS708 and TS709 provide inputs to the difference amplifier which is formed by TS713 and TS717, and whose operation depends upon the 'AFTER DELAY TIME' switch SK15 being set to its TRIGG position. The inputs to this difference amplifier may be changed over by operation of switch SK18 and this facility enables triggering to be effected on either the positive-going or negative-going edge of the input signal. The amplitude of the input signal is limited by diodes GR702 and GR703, which are connected in anti-parallel across the input contacts of switch SK18. The resulting signals on the collectors of TS713 and TS717 are opposite in polarity when the circuit is in operation, and are applied to the trigger multivibrator (Schmitt-trigger) which is formed by transistors TS714 and TS716.
When driven by the difference amplifier, the trigger multivibrator produces a square wave output of constant amplitude, whose relationship to the trigger input is determined by the LEVEL potentiometer R9.
If the 'AFTER DELAY TIME' switch SK15 is set to its STARTS position, the −24 V line to the difference amplifier circuit is interrupted and the difference amplifier is therefore blocked.

d. Differentiator stage

The constant amplitude square wave output taken from the trigger multivibrator output transistor TS716 is applied to the differentiator stage which includes TS718 and C721. The positive-going spikes are bypassed to earth by diode GR707, and the negative-going spikes are applied to the delayed time-base sweep gating multivibrator TS719 and TS721. Since the differentiator is driven from the trigger multivibrator, the negative-going spikes will only be present when the AFTER DELAY TIME switch SK15 is set to its TRIGG position.

e. Sweep gating multivibrator

With the AFTER DELAY TIME switch set to TRIGG, the negative-going differential spikes obtained from TS718 are combined with the hold-off circuit output in order to produce the control waveform for the delayed time-base sweep gating multivibrator. This multivibrator is formed by transistors TS719 and TS721 which are connected as a Schmitt-trigger. An additional transistor (TS720) whose base bias is set by the potential divider R793 and R794, acts as a current source for the Schmitt-trigger. The current source enables the sweep gating multivibrator to operate as a distinct level detector so that intermediate steps present in the control waveform do not appear at the collector of TS719.
The resulting unblanking waveform does not, consequently, contain any distortion which might cause unwanted intensification of the display. In addition to the unblanking waveform, the sweep gating multivibrator of the delayed time-base also supplies a waveform which drives the integrator circuit.
This signal is taken from the collector of TS721 and applied to the bases of transistors TS726 and TS733.
If the integrator control waveform is at its minimum positive level, TS726 and TS733 are cut off. The particular time capacitor connected into circuit by the delayed time-base TIME/div. switch SK11 is therefore charged by a linearily-increasing voltage and a delayed sweep is initiated.
This condition of the multivibrator (i.e. output of TS721 at its minimum positive level, causing a delayed sweep) is termed the 'set' condition.
With the delayed time-base in its other condition (output at maximum positive level) the time capacitor connected via the delayed time-base TIME/div. switch SK11 is totally discharged by TS726 and TS733. No delayed sweep is therefore initiated and this state of the sweep gating multivibrator is termed the 'reset' condition.

Assuming the Schmitt trigger to be in its 'reset' condition, the input signal must fall to a given switching level in order to change the Schmitt trigger to its 'set' state. Subsequent excursions of the input to this given switching level will not affect the Schmitt trigger. However, if the input signal rises to another given switching level, the Schmitt trigger will reset. The Schmitt trigger will then not revert to its 'set' state until the input voltage again falls to its 'set' switching level.
The two (set and reset) switching levels are disposed about a nominal +3 V level known as the 'set ready' level. The potential between the 'set' and 'reset' levels is termed hysteresis.
The input voltage which controls the sweep gating multivibrator is developed by combining the following sources:

– The trigger pulse train obtained from transistor TS718
– The d.c. level determined by the stabilization potentiometer R807 and applied by transistor TS722
– The hold-off circuit output, also applied via TS722
– A d.c. level obtained when the AFTER DELAY TIME switch SK15 is set to its STARTS position

The particular waveform combination and its level is determined by the setting of the AFTER DELAY TIME switch SK15. The trigger pulse train is not produced, and the level of the hold-off pulse is reduced, when SK15 is set to its STARTS position.

f. Integrator circuit

The integrator circuit is a section of the delayed time-base in which a linearily-increasing voltage is developed by means of the two voltage regulation transistors TS727 and TS728. These transistors cause a constant current to flow through the particular resistor which has been selected by the setting of the delayed time-base TIME/div. switch SK11. The exact current which passes through the selected resistor depends upon the voltages obtained from TS727 and TS728, and upon the value of the selected resistor.
The voltage derived from TS728 (and consequently the current through the selected resistor) is normally constant unless the TIME/div. control is moved from its CAL position. In this circumstance, the switch SK12 is opened and potentiometer R5 of the TIME/div. control may be used to adjust the voltage supplied by TS728. The base bias of TS727 is set by means of potentiometers R819 and R824 which are each connected between the +24 V line and earth. These potentiometers therefore provide an accurate means by which the current flowing through the selected resistor may be adjusted.

The current flow developed by the circuit which includes TS727 and TS728, is used to charge a time capacitor which is also selected by the TIME/div. switch of the delayed time-base. Since the current source maintains a constant value, the voltage across the time capacitor remains a linear increase throughout the charging period. The farther the TIME/div. potentiometer is advanced from its CAL position, the lower becomes the rate of voltage increase across the time capacitor.
Immediately the voltage across the time capacitor attains a given value, the hold-off circuit provides a level which is applied to the sweep gating multivibrator via transistor TS722. This causes the sweep gating multivibrator to change to its 'reset' condition, i.e. the output at the collector of TS721 is raised to its maximum positive level. Transistor TS726 switches hard on, and this causes the time capacitor to rapidly discharge. At the same time the current from TS727 is short-circuited to mass by TS726. It can therefore be seen that a sawtooth waveform is developed across the time capacitor. A further sawtooth sweep will be generated when the sweep gating multivibrator changes to its 'set' condition.

The delayed sweep waveform present at the emitter of TS731 is fed to the following points:
– Delayed time-base hold-off circuit in order to effect the discharge of the integrator time capacitor upon completion of a delayed sweep (and to hold-off the delayed time-base until the next main time-base sweep is running).
– Horizontal output amplifier, provided that the MAIN TB/DEL'D TB/EXTERN switch SK10 is set to DEL'D TB.

The 23 position DELAYED TIME-BASE TIME/div. switch SK11 provides a total of 22 calibrated deflection coefficients ranging from 0,5 s/div. to 0,05 μs/div., and also enables the delayed time-base to be switched OFF. The following table lists the components chosen for each of the 22 TIME/div. settings:

Components selected by the delayed time-base TIME/div. switch SK11

TIME/div. setting	*Delayed time-base capacitor between points A and B*	*Resistor between G and C*	*Connection (DE or DF)*
0.5 s/div.	C856	R862	DF
0.2	C856	R861	DF
0.1	C856	R859	DF
50 ms/div.	C856	R858	DF
20	C856	R851	DF
10	C856	R852	DF
5	C856	R853	DF
2	C851	R861	DE
1	C851	R859	DE
0.5	C851	R858	DE
0.2	C851	R851	DE
0.1	C851	R852	DE
50 μs	C851	R853	DE
20	C852	R851	DE
10	C852	R852	DE
5	C852	R853	DE
2	C853//C857	R851	DE
1	C853//C857	R852	DE
0.5	C853//C857	R853	DE
0.2	C854	R857	DE
0.1	C854	R856	DE
0.05	C854	R854	DE
OFF	SHORT CIRCUIT	OPEN	DE

g. Hold-off circuit

The delayed time-base hold-off circuit consists of a Schmitt trigger formed by transistors TS723 and TS724. This Schmitt trigger is controlled by a signal obtained from the reset multivibrator (of the main time-base), and by peaks of the delayed sweep voltage which are passed by diode GR709.

When the main sweep voltage exceeds a d.c. level determined by the DELAY TIME MULTIPLIER control, the comparator circuit causes TS933 of the reset multivibrator to conduct. The resulting fall in the hold-off circuit emitter potential reduces the collector potential of TS723 so that the hold-off level present at the emitter of TS722 is removed. This condition of the hold-off circuit (i.e. collector of TS723 at its lower level) is termed the 'set' condition, and its duration is dependent upon the following two factors:
– DELAY TIME MULTIPLIER control setting
– Delayed time-base TIME/div. switch
The maximum possible period in which the hold-off circuit can remain in its set condition is limited by the period of the main sweep.
In the STARTS mode of operation, the delayed sweep commences when the main sweep voltage exceeds a level determined by the setting of the DELAY TIME MULTIPLIER control.
The delayed sweep then continues to rise until its potential exceeds the cathode bias of GR709.
This causes a positive spike to be applied to the base of TS724. The collector of TS723 is then returned to its original (high) condition, and the hold-off circuit is reset. Because of this reset, the emitter potential of the hold-off circuit falls to its lower level (see the waveform relationship diagram of Fig. XIV-12). The emitter potential of the hold-off circuit returns to its high level immediately the main sweep is concluded. The hold-off level present at the emitter of TS722 is therefore maintained until a subsequent main sweep again exceeds the level set by the DELAY TIME MULTIPLIER control.

In the TRIGG mode of operation (AFTER DELAY TIME switch SK15 set to TRIGG) the hold-off circuit is set when the main sweep voltage exceeds the d.c. level determined by the DELAY TIME MULTIPLIER. However, a delayed sweep will not commence unless a trigger pulse appears during the 'set' period of the hold-off circuit. The delayed sweep is terminated in the same way as described for the STARTS mode.

h. Reset multivibrator

The reset multivibrator consists of a Schmitt trigger which is formed by TS932 and TS933, and which also includes TS942 connected in common base configuration (this circuit is located on the main time-base unit). Signals obtained from the sweep gating multivibrator and from the comparator are used to control the reset multivibrator, and the resulting output is used to drive the delayed time-base hold-off circuit as described in the previous paragraph.
When no main sweep voltage is being generated by the main time-base integrator circuit, the base of TS932 is supplied with a positive bias. Transistor TS932 is therefore conducting and TS933 is cut off.
There is no emitter current available to the delayed time-base hold-off emitter circuit, due to TS933 being cut off.
At the start of a main time-base sweep, the base bias of TS932 is reduced, although not to the extent which would cause TS933 to conduct. When the main sweep exceeds a level which is determined by the DELAY TIME MULTIPLIER, transistor TS943' of the comparator circuit is cut off. The current which was flowing through TS943' via resistor R1077 is then passed by transistor TS942, to the base of TS933. Transistor TS933 conducts and therefore acts as a current source for the emitters of the delayed time-base hold off circuit.

i. Comparator circuit

The comparator circuit includes a differential amplifier (TS943 and TS943') with an associated current source formed by TS947 (this circuit is also located on the main time-base unit).
The function of the comparator circuit is to switch the reset multivibrator in such a way that the delayed time-base hold-off circuit is operable only when the main sweep voltage exceeds the d.c. level set by the DELAY TIME MULTIPLIER potentiometer R4. It therefore initiates a delayed sweep in the STARTS mode of operation, or enables a trigger pulse to start a delayed sweep in the TRIGG mode.
The particular mode of operation is determined by the AFTER DELAY TIME switch setting.
Transistor TS949, whose base bias is set by potentiometer R1094, and transistor TS948, whose base bias is set by potentiometer R1090, act as voltage sources for the DELAY TIME MULTIPLIER potentiometer R4. Potentiometers R1090 and R1094 therefore enable the delay sweep to be set up during adjustment procedures.
The d.c. level taken from the wiper of potentiometer R4 is applied, by way of TS938' to the base of TS943'. This causes TS943 of the differential amplifier to remain blocked as long as the main sweep voltage present at its base does not exceed the voltage at the base of TS943'.
When the main sweep voltage at the base of TS943 exceeds the d.c. level applied to TS943', the differential amplifier changes state. Transistor TS943' is therefore blocked and this causes the reset multivibrator to change its state.

j. Operation of the delayed time-base

Introduction

The comparator circuit, and the reset multivibrator to which it is connected, controls the hold-off circuit of the delayed time-base.
This provides an interlock between the main and delayed time-bases, so that a delayed sweep can only be generated when a main sweep is taking place.

The delayed sweep is used (with the DELAY TIME–BASE switch SK11 in a setting other than OFF) to perform one of the two following functions:
– Intensification of a selected portion of the main time-base display (X DEFL. switch SK10 to MAIN TB)
– Full deflection of a selected portion of the main time-base sweep (X DEFL. switch SK10 to DEL'D TB)
The delayed time-base mode of operation depends upon the setting of the AFTER DELAY TIME switch SK15.

Delayed time-base triggering

When a suitable input signal is connected to channel A or channel B of the oscilloscope, trigger signals are produced by the trigger pick-off stage. These trigger signals drive the delayed time-base only if the AFTER DELAY TIME switch is set to TRIGG. In the TRIGG mode of operation, the trigger signal (channel A, channel B, or external) used to drive the delayed time-base is selected by means of the YA/YB/OFF switch SK16.
When the oscilloscope is operating in the differential mode, the trigger signal obtained from channel A is the difference signal.
Trigger signals applied to the trigger multivibrator of the delayed time-base are compared to a d.c. level which is determined by the setting of the LEVEL potentiometer R9, so that the display may be started from any point on the waveform. Switch SK18 may be used to invert the polarity of the trigger signal, and this facility enables triggering on the positive-going and negative-going edges of the signal.

Operation with the AFTER DELAY TIME switch set to STARTS

With the AFTER DELAY TIME switch set to the STARTS position, the delayed time-base sweep gating multivibrator is made inoperative and no trigger spikes are presented to the input of the sweep gating multivibrator. The application of a −24 V d.c. bias supply lowers the level of the delayed time-base hold-off circuit output sufficiently to enable the sweep gating multivibrator to be switched by the edges of the hold-off waveform.

Operation with the AFTER DELAY TIME switch set to TRIGG

With the AFTER DELAY TIME switch set to TRIGG, signals obtained from the trigger pick-off stage enable the delayed time-base trigger multivibrator to run. The resulting square wave output is differentiated in order to supply a series of negative-going spikes which are used to control the sweep gating multivibrator of the delayed time-base.
If the main time-base is not producing a main sweep, the hold-off circuit of the delayed time-base is blocked. This causes the input of the delayed time-base to be shifted to a level which is high enough to prevent the trigger spikes from having any effect upon the sweep gating multivibrator.
If a main sweep is started, the reset multivibrator will be switched over immediately the sweep voltage exceeds the d.c. level which is set by the DELAY TIME MULTIPLIER potentiometer R4. In the event of the DELAY TIME MULTIPLIER being set at a level which is not exceeded by the main sweep voltage, the reset multivibrator is switched over by an input derived from the integrator of the main time-base.
The reset multivibrator being switched causes the delayed time-base hold-off circuit output to fall to its 'set ready' level. The appearance of a trigger spike will then cause the sweep gating multivibrator to be switched over and a delayed sweep will therefore be initiated. The delayed sweep is terminated when the input from the integrator causes the output of the hold-off circuit to rise.
As the main sweep reaches its peak, the reset multivibrator is switched over so that the delayed time-base is blocked.
Should the main sweep be terminated during the rise of the delayed sweep, the delayed sweep will be terminated immediately.

F. HORIZONTAL AMPLIFIER

The main time-base, delayed time-base, or the Y_B channel may be chosen as an input source for the asymmetrically-driven push pull horizontal amplifier. The selected signal is applied to the base of TS1103 whose emitter circuit, together with that of TS1102, is fed from the current source stage TS1101. The emitter circuit negative feedback (and hence the deflection sensitivity of the horizontal amplifier) is set by potentiometer R1122.
Closure of relay RE1101, due to operation of the X MAGN PULL FOR x5 switch SK9, causes R1123, R1124 and R1128 to be inserted into the emitter circuit. This results in a decrease in negative feedback by a factor of 5, so that there is a corresponding increase in deflection sensitivity. Whilst relay RE1101 is energized, the MAGN ON indicator lamp is lit to show that the deflection coefficient has been increased.

If the main or delayed time-base has been selected as the input source, a d.c. level is applied to the base of TS1102 in order to set the horizontal trace. Adjustment of the d.c. level is effected by potentiometer R3.
With the X DEFL switch SK10 set to EXTERN via Y_B, the PULL FOR x5 switch SK9 is inoperative due to the removal of the +24 V supply.
In this mode of operation, the X POSITION potentiometer R3 is also disconnected from the circuit because horizontal display switching can be effected by means of the Y POSITION potentiometer R17.
The outputs obtained from TS1102 and TS1103 are used to drive the two output sections, TS1175, TS1176, and TS1177 which supplies plate x1 of the cathode ray tube, and TS1178, TS1179, and TS1180 which supplies plate x2.

G. UNBLANKING CIRCUIT

The unblanking pulses taken from the main and delayed time-bases by way of switch SK10, and the blanking pulses taken from the electronic switch driver via choke L501, are passed to the base of transistor TS1306. This transistor, together with TS1304, forms a cascode amplifier whose output is applied via TS1307 to a low-pass filter (R1320, R1324, R1325, C1305 and C1310). The filter enables the low frequency content of the cascode amplifier output to be fed to the modulator circuit, and also serves to prevent the 25 kHz carrier frequency from reaching the control grid of the cathode ray tube.

The modulator circuit, which is driven from a 25 kHz output taken from the convertor transformer TS1202, is formed by transistors TS1308 and TS1309. The low frequency content of the original waveform appears in a modulated form at the collector of TS1308 and is passed to a demodulation circuit (C1319, R1334, and GR1309) by means of emitter follower TS1309 and capacitor C1311.
The demodulated low frequency output is then mixed with the high frequency content of the original waveform which is present at the junction of R1334 and R1336. The resulting accurate replica of the original waveform is therefore presented at the control grid of the cathode ray tube.
The lower level of the waveform which is passed to the control grid of the cathode ray tube, is clipped by means of diode GR1309. The exact level of clipping is determined by the setting of the INTENS potentiometer which sets the bias of GR1309.

H. EXTERNAL Z MODULATION

External modulation voltages having either a low frequency or a d.c. component are connected to the Z MOD DC socket BU12 which is located at the rear of the instrument. Inputs to this socket are coupled to emitter followers TS1301 and TS1302. After amplification by TS1303 the signal is fed to the unblanking circuit.
A second socket (Z MOD AC, BU10) enables a.c. modulation signals to be connected via C1316 directly to the cathode of the cathode ray tube.
Socket BU10 is also located at the rear of the instrument.

I. CATHODE RAY TUBE CURRENT

1. Graticule illumination

Two lamps, LA1 and LA2, provide illumination for the graticule.
The lamps are connected in series to form the emitter follower load of transistor TS1228, and their brightness is controlled by means of the ILLUM potentiometer R8.

2. Beam correction coils

The toroidal magnetic field produced by winding L1302 enables the beam to be rotated for alignment purposes. The direction and degree of rotation is determined by the setting of potentiometer R1346.
The centre-tapped winding L1301 provides for the adjustment of trace deflection angle and vertical shift. Current flow through the two sections of winding L1301 is controlled by the setting of potentiometers R1343 and R1344.

3. Electrode circuits

Brightness control is by means of INTENS potentiometer R6, the control range of which is determined by R1327 and R1328. Focus is controlled by the FOCUS potentiometer R7, and astigmatism is corrected by use of R1341.

J. POWER SUPPLIES

1. General

These consist of a +24 V and +12 V supply, a −24 V and −12 V supply, a rectifier delivering +198 V and −198 V, and a high voltage chopper unit (U7).
The supply transformer is protected with a non-resetting thermal fuse (VL2).
From serialno. DQ1301 onwards the +24 V (+12 V) and −24 V (−12 V) have been modified for better current limitation.
The modified circuit diagram is given in Fig. XIV-15.
For current values see next table.

Supply	*Nominal current*	*Limiting current*	*Short-circuit current*
+24 V	1,7 A	2,5 A	0,5 A
−24 V	0,75 A	1,3 A	0,35 A

In Fig. XIV-16 the detailed circuit of the unmodified sets is given.

2. +24 V and +12 V supply

The +24 V output voltage is stabilised with the aid of the long-tailed pair TS1206 and TS1207 so that a part of the output voltage is compared with a reference voltage developed across Z-diodes GR1221 and GR1222.
Any difference signal is via TS1201 and TS1202 applied to the series-transistor TS1203.
The current is limited by TS1204 which is controlled by the voltage drop across R1201.
The +12 V supply is reduced from the +24 V by TS1209 and TS1208.

3. −24 V and −12 V supply

The −24 V output voltage is stabilised with the aid of a long-tailed pair TS1218 and TS1219 so that a part of the output voltage is compared with a reference voltage developed across Z-diodes GR1213 and GR1214.
Any difference signal is via TS1216 and TS1214 applied to the series-transistor TS1213.
The current is limited by TS1217 which is controlled by the voltage drop across R1234.
The −12 V supply is reduced from the −24 V by TS1220, TS1221 and TS1222.

4. High voltage chopper unit

This unit delivers +8500 V and −1600 V for the c.r.t., and +90 V and −90 V for the time-base and unblanking circuits (also the c.r.t. filament is fed by an a.c. voltage of 6,3 V from the chopper transformer).
The chopper operates at a frequency of approximately 25 kHz. The oscillator section of the chopper is formed by transistors TS1211 and TS1212, the oscillator transformer TS1202 and capacitor C1205.
Feedback is provided by connecting a winding of the transformer to the base circuits of TS1211 and TS1212.
Via R1248 the 25 kHz signal is applied to the modulator part of the unblanking circuit (see para G).
Parasitic oscillation is suppressed by R1220 (6,8 ohm).
The 1 ohm resistor R1215 serves merely as fuse if the chopper circuit is overloaded.

K. CALIBRATION VOLTAGE GENERATOR

The calibration source for the oscilloscope is obtained from a free-running multivibrator, consisting of transistors TS1223 and TS1224. A further two transistors (TS1226 and TS1227) are incorporated into the circuit to provide constant current sources.
The base bias of both current source transistors may be adjusted with the aid of potentiometer R1253 in order to set the amplitude of the square wave output. A second potentiometer (R1265) in the collector circuit of TS1223 enables the output frequency to be set at 2 kHz.
The 600 mV square wave output, taken from the emitter of TS1224, is available at the CAL socket BU3 which is located on the front panel beneath the screen bezel.

L. CIRCUIT DESCRIPTION PM 3250X

1. Introduction

This section describes the sync. separator, mains triggering and external horizontal input circuits which are exclusive to the X version of the PM 3250 oscilloscope. The section also details those modifications which have been made to the basic PM 3250 circuits in order to make them suitable for the PM 3250X.

2. Sync. separator

Input signals, taken from the contacts of the Y_A/Y_B/EXT. switch (SK2) are passed to the gate of field effect transistor TS2103. The source and drain voltages of this field effect transistor are in antiphase and it is therefore used to provide phase reversal. The appropriate switching is performed by means of diodes GR2101 and GR2102: these are opened and closed by a −24 V potential which is controlled by the PUSH FOR − VIDEO switch (SK32).
The selected phase is passed to the emitter follower TS2104 via C2106. The signal is then passed through a further four stages of amplification (TS2106, TS2107, TS2108 and TS2109) in which the unwanted 'white' portion of the signal is clipped by diodes GR2103 and GR2104.

Video field sync. pulses are formed by passing the signal present at the emitter of TS2109 to the integrator circuit formed by R2139, R2142, C2116, C2117, C2118, C2119 and diode GR2108. Note that the operation of the integrator circuit relies upon the reverse resistance of the OA95 diode (GR2108). The output of the integrator is passed to the emitter follower TS2111.

Operation of the PULL FOR TV FRAME switch (SK5) results in a −24 V potential being applied to field effect transistor TS2101 in order to isolate triggering inputs which are normally passed via the contacts of the LF/HF/DC switch (SK3).
At the same time, a −24 V potential opens switching diode GR2107, so that positive-going field sync. pulses from the emitter of TS2111 are coupled to TS908 of the main time-base. LEVEL pot. meter R1 is now out of service, because a d.c. level is generated with the aid of C2114, GR2106, R2108 and R2112.
When the oscilloscope is operating in the mains triggering mode (see para 3) switch SK5 is overriden and TS2101 is cut off. It is therefore impossible to cross-couple field sync. pulses with mains triggering signals.

Line sync. signals are obtained by means of an output taken from the junction of R2137 and R2138 and fed to the base of emitter follower TS2117.
The emitter output of TS2117 is fed to TS708 of the delayed time-base via diode switching circuit (GR2113).

When the PULL FOR TV LINE switch (SK19) is operated, a −24 V supply is connected to the gate of field effect transistor TS2116 so that the normal delayed time-base triggering inputs are isolated.
At the same time, a −24 V potential opens switching diode GR2113 in order to couple line sync. pulses to the base of TS708 of the delayed time-base.
LEVEL pot. meter R9 is now out of service, because a d.c. level is generated with the aid of C2132, GR2116, R2173 and R2178.
Because switches SK5 and SK19 are now used to provide sync. separator output selection, the triggering LEVEL x5 facility is not incorporated in the PM 3250X oscilloscope.

3. Mains triggering facility

The main time-base of the oscilloscope may be triggered by means of a mains frequency signal derived from winding S2 of supply transformer TS2101.
The mains frequency signal source is passed through a filtering and attenuation network before being fed to field effect transistor TS2102 which performs a gating function under the control of the PUSH FOR MAINS switch (SK33).

Operation of the PUSH FOR MAINS switch (SK33) causes the mains frequency triggering signal to be coupled to the base of transistor TS908 (main time-base) due to the gating action of field effect transistor TS2102. At the same time, contacts of the PUSH FOR MAINS switch SK33 also complete a pinch-off supply to a second field effect transistor (TS2101) in order to isolate the normal triggering circuit which are connected to the main time-base via the Y_A/Y_B/EXTERN and HF/LF/DC switches SK2 and SK3.
In addition to this, the PUSH FOR MAINS switch contacts also interrupt the −24 V control potential for the field sync. output switching diodes so that it is not possible to couple sync. separator outputs whilst the oscilloscope is operating in the mains triggering mode.

4. External horizontal input circuit

The external horizontal input circuit consists of a field effect transistor gating stage controlled by means of the X DEFL. switch SK10, and a preamplifier stage. An external horizontal input signal, connected to the oscilloscope by way of the main time-base TRIGG./EXT. X socket BU1, may be used to drive the horizontal output amplifier provided that the X DEFL. switch SK10 is set to its EXTERN position.
This facility, which replaces the EXTERN VIA Y_B function of the basic PM 3250 design, may be used in conjunction with a sweep generator in order to obtain a simultaneous display of two vertical signals.

The two-stage preamplifier circuit, formed by transistors TS2113 and TS2114, provides a x8 gain in order to compensate for signal attenuation in the input stage.

Preset potentiometer R20 which forms part of the horizontal preamplifier circuit, enables the gain to be set within the limits of 1,0 V/div. to 5,0 V/div. (0,1 V/div. to 0,5 V/div. if the MAGN. switch is set to its x10 position).
Trimmer R2152 enables the gain of the amplifier to be calibrated, with R20 set to its fully clockwise position.
The output of the preamplifier is connected to the main horizontal amplifier by way of switch SK10 contacts.

Input signals connected to the main time-base TRIGG./EXT. socket BU1 are passed to the preamplifier by means of the gating stage which is formed by field effect transistor TS2112, diodes GR2111 and GR2112, and resistors R2161, R2162, R2163 and R2164. TS2112 is protected against overvoltage with the aid of GR2109.
The gating stage is controlled by means of the X DEFL. switch SK10.

Setting the X DEFL. switch SK10 to its EXTERN position causes a positive potential to be removed from the anode of GR2112 and to be applied to the cathode of GR2111.

This change in bias results in field effect transistor TS2112 being opened so that the signal present at the TRIGG./EXT. X socket is coupled to the preamplifier. At the same time, the preamplifier is connected to the main horizontal amplifier via contacts of the X DEFL. switch SK10.

5. Circuit modifications

The following modifications have been made to the basic PM 3250 circuit assemblies in order to make them suitable for the X version:

Added: — a printed circuit board (U43) containing the various circuits related to the PM 3250X version.
— a pot. meter (R20) mounted at the right-hand side of the cabinet, used as attenuator for the external horizontal amplifier.

Modified:

a. Supply unit U1

The following components have been connected across winding S2 of transformer T1201 in order to pick off the mains frequency signal for the mains triggering facility:

a. capacitor C2113, 0,33 μF ±10 %, 400 V
b. resistor R2106, 120 kΩ, 5 %, CR25
c. 50 Ω cable to unit U10

b. Time-base U10

The values of capacitors C906 and C908 in the TRIGG./EXT. X input circuit are changed as follows:

a. C906 becomes 15 pF
b. C908 becomes 5,6 pF
c. Resistors R742 and R942 (used in the basic PM 3250 to provide the triggering level x5 magnification facility) have been removed.

c. Delayed time-base U11 (part of unit U10)

This unit is termed U11X after incorporation of the following modifications:

a. An additional resistor R2167 and field effect transistor TS2116 (part of the delayed time-base trigger gating circuit) have been added.
b. Resistor R741 becomes 11 kΩ, 5 %
c. The printed wiring has been modified as detailed in Fig. XIV-20.

d. Main time-base U12 (part of unit U10)

This unit is termed U12X after incorporation of the following modifications:

a. Resistor R941 becomes 11 kΩ, 5 %
b. Resistor R1124 becomes 750 Ω, 1 % (x10 MAGN. modification)
c. An additional resistor R2102 and field effect transistor TS2101 (part of the main time-base trigger gating circuit) has been added.
d. The printed wiring has been modified as detailed in Fig. XIV-19.

e. Intermediate amplifier U26

This circuit board assembly has been modified as follows:

— Transistors TS514, TS1151 and TS1152 have been removed.

X. Dismantling

A. GENERAL

This section provides the dismantling procedures required for the removal of components during repair operations. All circuit boards removed from the oscilloscope should be adequately protected against damage, and all normal precautions regarding the use of tools must be observed. During dismantling procedures, a careful note must be made of all disconnected leads so that they may be reconnected to their correct terminals during assembly.

When removing the anode connector of the c.r.t., be sure to discharge both the anode contact of the c.r.t. and the anode connector as well.

Note: It takes several seconds for complete discharging of the c.r.t. and the h.t. supply.

To remove the anode connector of the c.r.t., first compress the spring which is concealed beneath the insulation cover. The connector must then be eased upwards and then downwards in order to release the prongs of the spring from the recess in the c.r.t.

Damage may result if the equipment is switched on whilst a circuit board is removed, or if a circuit board is removed before one minute after the oscilloscope has been switched off.

B. REMOVING THE COVER PANELS AND THE SCREEN BEZEL

The upper and lower cover panels may be removed when four quick-release fasteners, located one in each corner of its panel, are released. When fitting the covers, rotate the fasteners until a click is heard.
The screen bezel may be sprung from its position by pulling at its lower edge. When fitting the bezel, note that its position depends upon whether or not a filter has been incorporated. The correct position is indicated by arrows which are printed on the inner surface of the bezel.

C. REMOVING THE KNOBS (Fig. X-1)*

The knobs may be removed as follows:

1. **Single knobs**
   - Prise of the cap, A
   - Loosen the screw (or nut), B
   - Pull the knob from its spindle

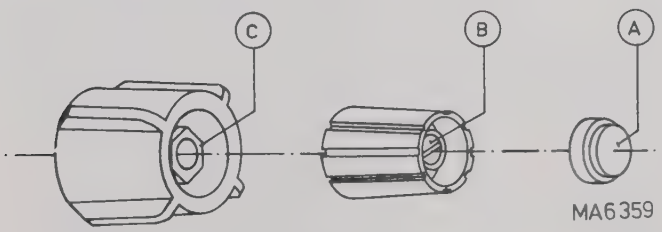


Fig. X-1. Removing the knobs

* The INTENS, and FOCUS knobs can simply be pulled-off.

2. Double knobs

– Prise off cap A and loosen screw B
– Pull the inner knob from its spindle
– Loosen nut C and pull the outer knob from its spindle
When fitting a knob or cap, ensure that the spindle is in a position which allows reference lines to be coincident with the markings on the panel of the oscilloscope.

3. Delay time multiplier knob (Fig. X-2)

– Slacken screw D using an hexagonal key, and pull the knob from its spindle
– Remove the nut E and withdraw the ring from its spindle
When fitting this vernier control, turn the spindle of its potentiometer fully anticlockwise. Place the ring on the shaft so that its reference line corresponds to the zero mark on the calibrated scale then lock it with nut E. Fit the inner knob so that its cam is engaged with the groove of the ring. Turn the inner knob until its zero mark is coincident with the reference line on the ring. Secure the assembly by tightening screw D.

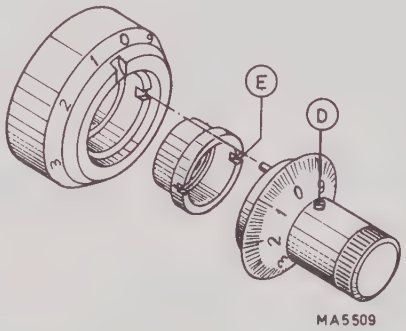


Fig. X-2. Delay time multiplier vernier knob

D. REMOVING THE TIME-BASE UNIT

– Remove the time-base knobs, and unscrew the collars from the X POSITION and LEVEL potentiometers
– Remove the mains cable housing F by unscrewing four screws G, see Fig. X-3

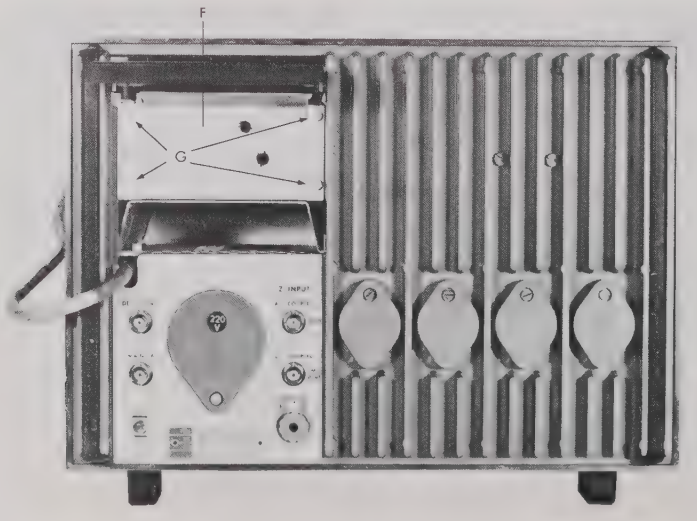


Fig. X-3. Rear side view

– Remove five screws which secure the two narrow text plates at the side of the time-base
– Disconnect six coaxial plugs and one wire connector from the underside of the unit
– Disconnect four coaxial plugs and two wire connectors from the top of the unit
– Remove the screw which secures the time-base unit to the front panel of the oscilloscope
– Disconnect the connector socket at the rear of the centre partition. Note that this connector socket can only be withdrawn when its two keyways are compressed sufficiently to release the internal catches
– Tilt the time-base unit at its rear and withdraw it from the oscilloscope

When fitting a time-base unit, its switch toggles should be set to their mid position. The toggles are then easier to insert into their slots.

E. REMOVING THE INTERMEDIATE AMPLIFIER AND ELECTRONIC SWITCH DRIVER CIRCUIT BOARD (UNIT 26) see Fig. X-4

– Remove relevant channelled base strip I by removing three screws H
– Remove the blue screening cover from the electronic switch driver circuit
– Disengage the switch actuating mechanism
– Unsolder all connecting leads, and disconnect two coaxial leads and two wire connectors carefully noting all disconnecting leads
– Remove the six screws which secure the board

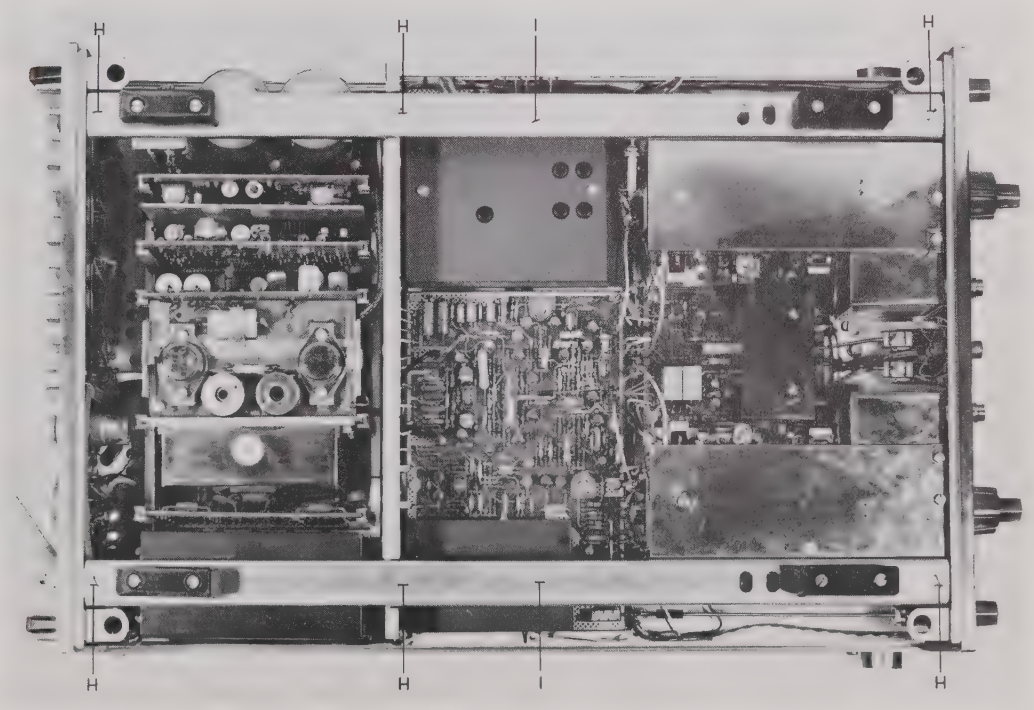


Fig. X-4. Bottom side view

F. REMOVING THE DRIFT REDUCTION AMPLIFIER CIRCUIT BOARD (UNIT 36) see Fig. X-4

– Remove relevant channelled base strip I by removing three screws H
– Remove the blue screening cover from the circuit board
– Disengage the switch actuating mechanism
– Unsolder all connecting leads carefully noting all leads
– Remove the four screws which secure the board

G. REMOVING THE TRIGGER PICK-OFF STAGE

- Remove the screening cover
- Unsolder all external leads and disconnect four wire connectors carefully noting all leads
- Disengage the switch operating mechanisms
- Remove the four fixing screws

H. REMOVING THE ATTENUATOR UNITS

- Remove the knobs from the appropriate AMPL control (see para **C**)
- Remove the appropriate channelled base strip I
- Remove four screws in order to free the two screening covers
- Remove two screws which secure the attenuator to the front panel
- Disconnect two coaxial plugs and six wire connectors
- Remove the two screws which attach the attenuator to the base of the oscilloscope. Withdraw the attenuator

When an attenuator is being fitted, care must be taken to ensure that the input socket screen is properly engaged with its fixing clip.

I. REMOVING THE DELAY LINE (L603), see Fig. X-5

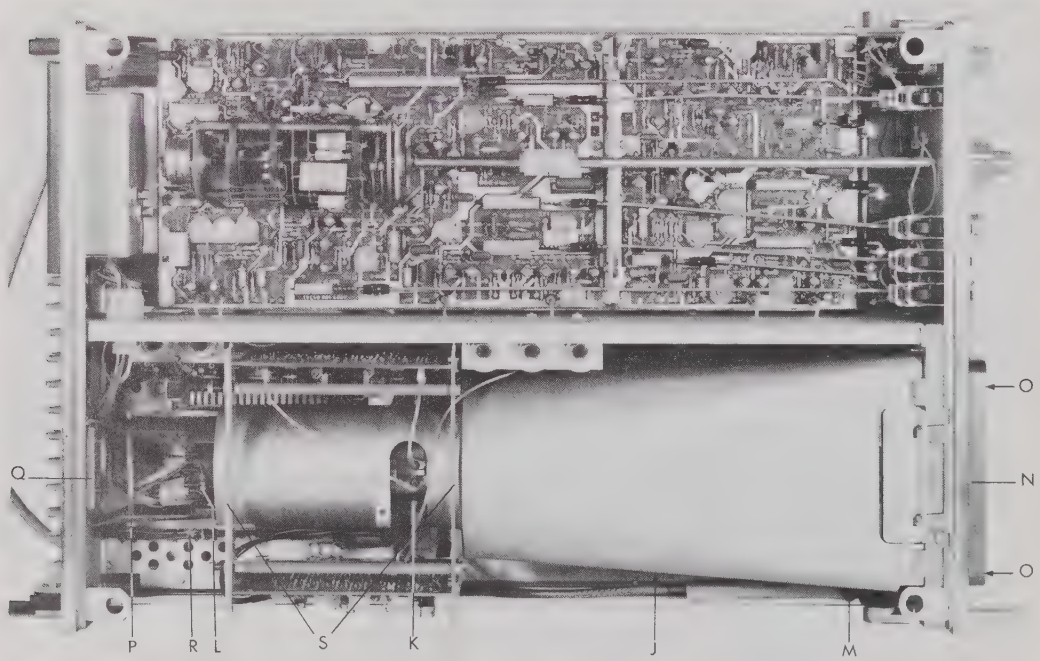


Fig. X-5. Top side view

The delay line is located between the c.r.t. and the calibration unit (U9).

- Remove two screws and withdraw the metal delay line bracket J.
- Remove the calibration unit (first remove the securing clip)
- Disconnect the delay line coaxial plugs from the vertical output amplifier and from the intermediate amplifier
- Withdraw the delay line

J. REMOVING THE POWER SUPPLY UNIT

– Remove the channelled strips I from the bottom side of the oscilloscope
– Disconnect the c.r.t. anode connector

When removing the anode connector of the c.r.t., be sure to discharge both the anode contact of the c.r.t. and the anode connector as well.

Note: It takes several seconds for complete discharging of the c.r.t. and the h.t. supply.

– Remove the two fixing screws which are adjacent to the electrolytic capacitors, and remove the three fixing screws which are adjacent to the mains transformer. Pull the e.h.t. connector through from the frame
– Partly withdraw the supply unit in order to gain access to the rear side of the mains voltage selector. Unsolder the black lead to the fuse holder and the black lead to the voltage selector.
– Free the voltage selector by removal of its two screws. Withdraw the power supply unit.

When replacing the voltage selector, check that it is fitted in the correct position.

K. REMOVING THE CATHODE RAY TUBE (Fig. X-5)

– Pull the five connectors K from the pins at the side of the c.r.t.
– Disconnect the socket L from the base of the tube
– Remove the anode connector M from the anode of the tube. To do this compress the spring which is beneath the insulation cover and then ease the connector upwards and downwards in order to release the prongs of the spring from the recess in the c.r.t.

When removing the anode connector of the c.r.t., be sure to discharge both the anode contact of the c.r.t. and the anode connector as well.

Note: It takes several seconds for complete discharging of the c.r.t. and the h.t. supply.

– Remove the screen bezel N by pulling at its lower edge
– Release the illumination wedges O by removing their securing springs
– Loosen the clamping screw P of the end bracket assembly
– Ease the tube forward taking great care not to engage its side pins with the shield. Unsolder the correction coil leads and then withdraw the tube.
Note that the bezel and illumination wedges mentioned in the above paragraph must be removed in order to renew defective graticule lamps. When a tube is fitted, the bezel must first be fitted with its 'top no filter' arrow pointing upwards: this allows the face of the tube to be located in its correct position.

L. REMOVING THE C.R.T. SHIELD (Fig. X-5)

– Remove the c.r.t. as instructed in para K
– Loosen the two screws and plate Q which clamp the c.r.t. bracket to the rear plate
– Remove the screw R and rubber pad by which the shield is attached to the bracket
– Push the screen rearwards so that it may be tilted and then withdrawn. Great care must be taken not to strain any leads whilst the shield is being removed.

When a c.r.t. shield and bracket are being fitted, the screws must not be tightened otherwise the assembly cannot be centralized following the insertion of the c.r.t.

M. REMOVING THE HORIZONTAL AND VERTICAL OUTPUT AMPLIFIERS (Fig. X-5)

– Pull off the securing bracket S
– Remove two coaxial plugs of the delay line and disconnect the blue and grey leads from the vertical output amplifier.
Withdraw the vertical output amplifier circuit board.
– Disconnect the orange and yellow leads before removing the horizontal output amplifier

N. POWER ON SWITCH, INTENS, FOCUS, AND ILLUM POTENTIOMETERS

Access to the POWER ON switch, its associated indicator lamp and the INTENS, FOCUS, and ILLUM potentiometers may be gained upon removal of the c.r.t. and its shield (paras K and L)

O. POWER TRANSISTORS

The power transistors fitted to the heat sink at the rear of the oscilloscope are plugged-in, and secured by two screws; one of these screws also holds the insulating cover. When fitting a new transistor, care must be taken not to omit the mica washer and the insulating ring (they serve for electric insulation).

XI. Checking and adjusting

A. GENERAL

The following information provides the complete checking and adjusting procedure for the /04 versions of the PM 3250 oscilloscope. Because some of the circuits are interdependent, a certain order of checking and adjusting is often required. The procedures are, therefore, presented in a sequence which is best suited to this order and cross-reference is made to any circuit which may influence a particular adjustment. Prior to checking and adjusting a particular circuit, care must be taken to ensure the accuracy of all associated circuits.
The tolerances stated in the checking and adjusting procedures apply only to instruments which are completely adjusted, and may differ from the data given in Chapter SPECIFICATION of this manual.
Only skilled personnel familiar with the risks of shock should perform those adjustments which necessitate the removal of covers from an oscilloscope which is connected to the mains. In all other circumstances, covers should remain fitted as long as the instrument is live.
Check that the position of the voltage selector at the rear of the instrument corresponds to the local mains voltage (check also the correct value of the mains fuse).
In general a preliminary warm-up time of at least one hour is recommended.
Before checking or adjusting any circuit be sure that the instrument is in reasonable working condition.
After adjustment of preset potentiometers do not forget to refit the dust caps.

All preset potentiometers, select-in-test resistors and trimming capacitors are indicated in Fig. XI-8.
All controls mentioned in the 'checking and adjustment' procedure without item numbers, are located on the front panel.
Unless otherwise stated, the front panel controls must set to in following positions:
– Trigger switches of the main time-base to positions: AUTO, Y_A, LF and +.
– MAIN TIME BASE switch to 1 ms/div. (cont. control to CAL.).
– X DEFL. switch to MAIN TB.
– DELAY TIME multiplier to 0.
– Trigger switches of the delayed time-base to: STARTS, Y_A, LF and +.
– DELAYED TIME-BASE switch to OFF (cont. control to CAL.).
– GAIN switch to: x1
– CHOPP./ALT. switch to: ALT.
– Both AC/0/DC switches to: AC.
– Switch A/OFF/A–B to A.
– Switch B/OFF/–B to OFF.

B. SUPPLY UNIT

Only the +24 V and –24 V output voltages of the supply unit are adjustable. All other supply voltages are derived from the said voltages, except the + and –198 V.

Required instruments:
– A mains voltage meter
– A d.c. measuring instrument
– If one wants to check the stabilisation properties of the supply unit, moreover, a variable transformer (100 VA) and a high-sensitivity voltmeter (preferably a digital voltmeter) are required.

Supply voltages

Supply voltage	*Tolerance*	*Test point*	*Max. perm. ripple voltage*
+12 V	±0,5 V	Terminal board, blue lead [1]	2 mV_{p-p}
−12 V	±0,5 V	Terminal board, grey lead [1]	2 mV_{p-p}
+24 V	±0,1 V	Terminal board, red lead [1]	2 mV_{p-p}
−24 V	±0,1 V	Terminal board, yellow lead [1]	2 mV_{p-p}
+90 V	±3 V	Terminal board, purple lead [1]	0-0,5 V_{p-p} depending on sweep times
−90 V	±3 V	− C1308 unit U3, rear side of board	0-0,5 V_{p-p} depending on sweep times
+198 V	−	+ C1211, orange lead [2]	1 V_{p-p}
−198 V	−	− C1208, white lead [2]	1 V_{p-p}

[1] Test points on terminal board, located underneath the c.r.t., and behind the delay line and unit U9.

[2] See Fig. XI-1.

Adjusting the +24 and −24 V

For test points see table above.
Adjust R1208/U2 for +24 V.
Adjust R1242/U2 for −24 V.

Mains voltage influence

Vary the mains voltage + and −10 % of the nominal value using a variable transformer; the +24 V and −24 V supply variation should be less than 0,1 %

Power consumption

Check that the mains current at 220 V mains voltage, 50 Hz does not exceed 550 mA (use a soft-iron meter only).

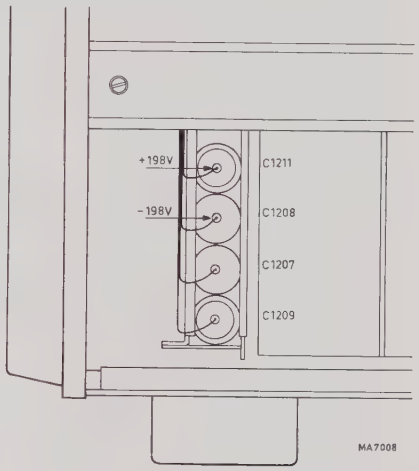


Fig. XI-1. Measuring the +198 V and −198 V

C. CATHODE RAY TUBE CIRCUIT

Introduction

In this chapter following checks and adjustments are discussed:
1. Intensity R1327/U9, R1328/U9, (R6)
2. Unblanking (Z-amplifier) C1306/U3, C1307/U3, R1308/U3, R1321/U3
3. Focus and Astigmatism R1337/U9, R1341, (R7)
4. Trace rotation, Orthogonality and Pattern distortion R1346, R1343, R1344, R1339
5. Gain and h.f. response of the vertical amplifier
6. Gain and linearity of the horizontal amplifier and the time-base.

In principle, the above-mentioned points are necessary when the C.R.T. has been replaced; they apply equally to C.R.T. versions −BE/09 and −GM/09.

Required instruments:
A sine wave generator (2 kHz)
A d.c. voltmeter

1. Intensity

The control range of the intensity control on the front panel is adjusted with R1327 (+) and R1328 (–) located on calibration unit U9.

WARNING: Use a well-insulated trimming tool, as these potentiometers carry 1600 V.

– Both AC/0/DC switches to 0
– A/OFF/A–B switch to OFF
– B/OFF/–B switch to B
– X DEFL. switch to EXTERN via Y_B
– Centre the spot with the Y_B POSITION potentiometer
– Rotate potentiometer INTENS. on the front until it is 90^o from its fully-anti-clockwise position.
– Adjust R1327 (+) to the position at which the spot is just visible.
– MAIN TIME-BASE switch to 1 ms/div.
– DELAYED TIME-BASE switch to 1 μs/div.
– X DEFL. switch to DEL'D TB.
– Potentiometer INTENS. fully clockwise.
– Display the beginning of the trace using the X POSITION potentiometer.
– Adjust R1328 (–) to the position at which a dot, at the beginning of the trace, becomes just visible.
Repeat the whole procedure until optimum results are obtained.

2. Unblanking (Z-amplifier)

Equal brightness of the trace is adjusted with R1321, C1306 and C1307.
– MAIN TIME-BASE switch to 10 ms/div.
– Check that the trace is of equal brightness throughout.
– Any necessary adjustment can be made with potentiometer R1321 (if necessary change R1325).
– Repeat adjustment of intensity para a and above mentioned adjustment in order to obtain optimum results.
– MAIN TIME-BASE switch to .05 μs/div.
– Check that the trace is equally bright over the whole length (uniform thickness).
If necessary, correct with trimmers C1306 and C1307.
– X MAGN. switch to x5 (knob pulled out).
– When the INTENS. potentiometer is turned from max. brightness to the intensity at which the trace is just visible, only the first two divisions of the total trace are allowed to become invisible (if necessary, adjust C1306 and C1307).

3. Focus and astigmatism

Focus and astigmatism are adjusted with R7 (front panel) and with R1341 (centre mounting plate) respectively.
– Apply a 2 kHz sine-wave signal (100 mV) to input Y_A; set the Y_A AMPL. switch for a six division peak-peak vertical deflection.
– Set the TIME/div. switch of the main time-base and the LEVEL potentiometer to a position which enables several complete cycles to be displayed.
– Set the INTENS. potentiometer on the front for normal brightness.
– Adjust the FOCUS potentiometer in conjunction with ASTIGM. pot. meter R1341 in order to obtain a reasonably sharp clearly - defined trace (check also at minimum and maximum intensity, using R6 and R7 only; if necessary change R1337/U9.

4. Trace rotation (R1346), Orthogonality (R1343, R1344) and Pattern distortion (R1339)

These potentiometers are located on the centre mounting plate.
– Both AC-0-DC input switches to 0.
– Both input switches A/OFF/A–B and B/OFF/–B to OFF.
– The potential between the plates of the vertical deflection must now be 0 volt; if not, adjust the vertical amplifier, see chapter D.5.
– R1339, R1343, R1344 and R1346 to mid-position.
– Adjust R1346 so that the trace runs exactly in parallel with the horizontal lines of the graticule; centre the trace with R1343 and R1344.
– A/OFF/A–B switch to A.
– B/OFF/–B switch to B.

– Shift both traces to the horizontal centre-line with the aid of the POSITION potentiometers (during the following of this particular procedure do not readjust these potentiometers anymore).
– AC-0-DC switch of channel A to AC.
– In order to obtain a display useful for orthogonality adjustments, apply a 2 V_{p-p} sine-wave signal (freq. ≈ 2 kHz) to the Y_A input and set Y_A AMPL. switch to 20 mV/div.
– Adjust the orthogonality potentiometers R1343 and R1344 so, that the vertical centre lines of the A-trace run exactly in parallel with the vertical lines of the graticule; the B-trace must remain on the horizontal centre line; also adjust R1346 to obtain a display in parallel with the horizontal lines of the graticule.
– Adjust R1339 (PATT. DIST.) in order to obtain an undistorted display.
– Set the signal generator for a frequency between 100 kHz and 200 kHz, and the Y_A AMPL. switch for a trace height of approximately 8 div.
– If necessary, re-adjust R1339 in order to reduce barrel an pin-cushion effects to minimum.

5. **Gain and h.f. response of the vertical amplifier**

Refer to chapter D.6.

6. **Gain and linearity of the horizontal amplifier and the time-base**

Refer to chapter H.

D. VERTICAL DEFLECTION

The various checking and adjusting procedures to be applied to the amplifiers and attenuators of channel A and channel B are identical. The following instructions are, therefore, presented for channel A; relevant channel B controls are stated in brackets where applicable.
Separate instruction is given whenever differences arise between versions.
Prior to adjusting the square-wave response of the vertical amplifiers, ensure that the main time-base and horizontal amplifier are operating correctly.
When one or more transistors or other components have been replaced in the vertical amplifiers the h.f. response must be checked.

1. **Pre-amplifiers**

In this chapter the following checks and adjustments are discussed:

a. D.C. balance
b. D.C. symmetry level
c. L.F. response
d. Gain
e. Overshoot compensation of the input attenuators
f. Input capacitance

Required instruments:

A calibrated square-wave generator (10 Hz - 10 kHz)
A d.c. voltmeter (free from earth)

a. D.C. balance

The d.c. balance is adjusted with the DC BAL. preset potentiometers on the front panel.
– GAIN switch to x10.
– AMPL. switches to 2 mV/div.
– Both cont. controls of the attenuator to position CAL.

Channel A:

– Switch A/OFF/A–B to A.
– Switch B/OFF/–B to OFF.
– Position the trace on the screen with the Y_A POSITION potentiometer.
– Adjust DC BAL. potentiometer R11 so that the trace does not jump when the relevant AC/0/DC switch is switched between the 0 and the DC position.

Channel B:

– Switch B/OFF/–B to B.
– Switch A/OFF/A–B to OFF.
– Position the trace on the screen with the Y_B POSITION potentiometer.
– Adjust DC BAL. potentiometer R12 so that the trace does not jump when the relevant AC/0/DC switch is switched between the 0 and the DC position.

Check also the d.c. balance of the drift reduction amplifiers, see chapter 2.

b. D.C. symmetry level

This is the symmetry of the balance circuit of the pre-amplifiers (in conjunction with the drift reduction amplifiers); check that the d.c. balance of the pre-amplifiers (point a) is in order.
– AC/0/DC switches to position 0.
– Switch A/OFF/A–B to OFF
– Switch B/OFF/–B to OFF

Channel A:

– Connect a d.c. voltmeter (free from earth) between the junctions R137-R138 and R156-R157.
– Change R145 until this voltage is zero (+ or –0,5 V).

Channel B:

– Connect a d.c. voltmeter (free from earth) between the junctions R337-R338 and R356-R357.
– Change R345 until this voltage is zero (+ or –0,5 V).

c. L.F. response

The l.f. response of the vertical amplifier is adjusted with potentiometer R122 (R322) and R143 (R343) located on the pre-amplifiers.
– MAIN TIME-BASE switch to 20 ms/div.
– Apply a square wave with an amplitude of 300 mV from zero and with a frequency of 10 Hz to the Y_A (or Y_B) input.
– Set the relevant AMPL. switch to 20 mV (cont. control in position CAL.).
– Both AC/0/DC switches to DC.
– Set the POSITION potentiometer in order to display the earth part of the signal.
– Adjust potentiometer R122 (R322) for a straight top; if necessary, change R123 (R323).
– Decrease the amplitude of the input signal to 30 mV.
– AMPL. switch to position 2 mV/div.
– Adjust the POSITION potentiometer in order to display the earth part of the signal.
– Adjust potentiometer R143 (R343) for a straight top. Check also in positions 5 mV/div. and 10 mV/div. of the AMPL. switch.

d. Gain

Channel A or B
The gain of the pre-amplifiers is adjusted with the GAIN ADJ. preset potentiometers R10 and R13 on the front panel.
– GAIN switch to x1.
– Set the relevant AMPL. switch to 0.1 V/div.
– Set the relevant AMPL. fine control to position CAL.
– Connect the CAL. socket to the relevant Y input.
– Set the GAIN ADJ. potentiometer for a trace height of exactly six divisions.
Check that there is still a measure of control (approx. 30^{o}) left.

If necessary, also the gain of the intermediate amplifier must be adjusted.
Refer to chapter D.3.c.

e. Overshoot compensation of the input-attenuators

– MAIN TIME-BASE switch to 50 μs/div.
– Apply a 10 kHz square-wave signal (rise time less than 200 ns) to the desired Y-input socket.
– Adjust the attenuator in accordance with the following table, so that no overshoot occurs:

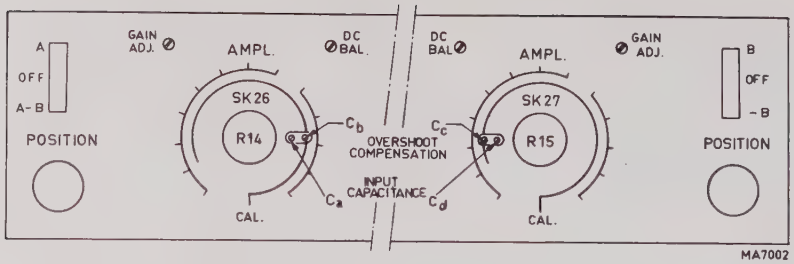


Fig. XI-2. Input and compensation capacitors

AMPL. switch set at	*Input voltage*	*Adjust with Cb - (Cc) (see Fig. XI-2)*		*Trace height required (divs. ±2 %)*
2 mV/div.	12 mV_{p-p}	C64 (C264)	C108 See note (C308)	6
5	30	C63 (C263)		6
10	60	C60 (C260)		6
20	120	C55 (C255)		6
50	300	C52 (C252)		6
.1 V/div.	600	C48 (C248)		6
.2	1,2 V_{p-p}	C46 (C246)		6
.5	3	C42 (C242)		6
1	6	C39 (C239)		6
2	12	C36 (C236)		6
5	30	C33 (C233)		6
10	60	C29 (C229)		6
20	80	C27 (C227)		4

Note: C108 (C308) for coarse adjustment; C64 etc. for fine adjustment.

Use the trimming rod supplied with the oscilloscope.

f. Input capacitance

The input capacitance of the oscilloscope must have the same value for all positions of the input AMPL. switches. This capacitance need not be exactly 20 pF, because a measuring probe can be adjusted to the input capacitance of an oscilloscope.

Preferably both Y_A and Y_B inputs must have the same input capacitance.

The equality of the various input capacitances can be checked and adjusted with e.g. capacitance measuring bridge. The capacitors in following table must be so adjusted that the input capacitance is the same for each position of both AMPL. switches.

If desired a 1 MΩ//20 pF measuring probe or a standardizer 1 MΩ//20 pF (TEK 067 - 538 - 00) can be used, in conjunction with a square-wave generator.

In this case, the capacitors in following table must be so adjusted that no distortion occurs.

AMPL. switch set at	*Input voltage*	*Adjust with Ca - (Cd) See Fig. XI-2*	*Trace height required (divs. ±2 %)*
2 mV/div.	12 mV_{p-p}	C61 (C261)	3
5	30	C58 (C258)	3
10	60	C56 (C256)	3
20	120	C53 (C253)	3
50	300	C51 (C251)	3
.1 V/div.	600	C47 (C247)	3
.2	1,2 V_{p-p}	C44 (C244)	3
.5	3	C41 (C241)	3
1	6	C38 (C238)	3
2	12	C34 (C234)	3
5	30	C32 (C232)	3
10	60	C28 (C228)	3
20	80	C26 (C226)	2

Use the trimming rod supplied with the oscilloscope.

2. Drift reduction amplifiers

These circuits are provided with following adjusting possibilities:

a. D.C. balance
b. Chopper signal suppression

a. D.C. balance

– Set the relevant AMPL. switch on the front panel to 2 mV/div.
– Set the relevant AC/0/DC switch to 0.
– Set the GAIN switch to x10.
– No trace displacement may occur when the AMPL. switch is transferred from 2 mV/div. to 20 mV/div. and back.
This can be adjusted with potentiometer R1406 (R1419)
Check also the d.c. balance of the pre-amplifier.

b. Chopper signal suppression

– Set the relevant AMPL. switch on the front panel to 2 mV/div.
– Set the relevant AC/0/DC switch to DC.
– Set the GAIN switch to x10.
– Set main time-base switch to .5 ms/div.
– The display can be triggered by putting an insulated piece of wire, connected to the trigger input socket, through the indicated hole of the screening plate of the drift reduction circuits.
– Adjust trimmer C1403 (C1422)

Repeat the d.c. balance of both the pre-amplifiers and the drift reduction amplifiers, as well as the chopper signal suppression adjustments in order to obtain optimum results.

3. Intermediate amplifier

The intermediate amplifier is provided with the following adjusting possibilities:

a. Shift symmetry
b. Shift range
c. Gain
d. H.F. response
e. EXT. via Y_B

Required instrument:

A calibrated sine-wave generator (120 mV_{p-p} - 480 mV_{p-p}/2 kHz)

a. Shift symmetry

– Set the Y AMPL. switches to 20 mV/div. (cont. control to CAL.).
– GAIN switch to x10.
– Both AC/0/DC switches to 0.
– A/OFF/A–B to A.
– B/OFF/–B to B.
– Use both Y POSITION knobs to shift the traces onto the screen.
– When the A/OFF/A–B switch is switched from A to A–B and back the A-trace may not jump more than two divisions.
If necessary adjust R1623.
– A/OFF/A–B switch to A.
– When rotating the Y_A AMPL. cont. control knob the A-trace may not shift more than 0,4 div.
If necessary change R1600.
– When the B/OFF/–B switch is switched from B to –B and back the B-trace may not jump more than two divisions.
If necessary adjust R475.
– B/OFF/–B switch to +B.
When turning the Y_B AMPL. cont. control knob the B-trace may not shift more than 0,4 div.
If necessary change R452.

b. Shift range

– Both Y AMPL. switches to 20 mV/div.
– GAIN switch to x1.
– A/OFF/A–B switch to A.
– B/OFF/–B switch to OFF.
– Apply a 480 mV_{p-p} 20 MHz sine-wave signal to the Y_A input.
– Check whether the display can be shifted symmetrically over the screen using the Y_A POSITION knob.
If necessary change R413 or R418.
– A/OFF/A–B switch to OFF.
– B/OFF/–B switch to B.
– Apply the 480 mV_{p-p} 20 MHz sine-wave signal to the Y_B input.
– Check whether the display can be shifted symmetrically over the screen using the Y_B POSITION knob.
If necessary change R486 or R491

c. Gain

Gain adjustment is only possible if the l.f. response of the pre-amplifiers is well adjusted (see chapter D1.c.).
– AC/0/DC switches to DC.
– A/OFF/A–B switch to A–B.
– B/OFF/–B switch to OFF.
– GAIN switch to x1.
– Both Y AMPL. switches to 20 mV/div. (cont. control to CAL.).
– Apply a 2 kHz sine-wave signal having an amplitude of exactly 120 mV_{p-p} to the Y_B input.
The vertical deflection must now be exactly six divisions.
This can be adjusted with the Y_B GAIN ADJ. screw driver adjustment (at the front) which must be approximately in the middle position.
If necessary change R455.
– B/OFF/–B switch to B.
The vertical deflection of the second waveform which appears now must be also exactly six divisions.
If necessary change R495.
– Remove the signal from the Y_B input and apply it to the Y_A input.
The vertical deflection must be again exactly six divisions.
This can be adjusted with the Y_A GAIN ADJ. screw driver adjustment (at the front), which must be approximately in the middle position.
– A/OFF/A–B switch to A.
The vertical deflection must be exactly six divisions.
If necessary change R1615 (or R1614).
– GAIN switch to x10.
– A/OFF/A–B switch to A–B.
– Reduce input signal to exactly 12 mV_{p-p}.
The vertical deflection must be exactly six divisions.
If necessary change R443.

d. H.F. response

Refer to chapter D.6.

e. EXT. via Y_B

Refer to chapter H.d.

4. Chopper circuit

This circuit (unit U26a) contains no adjusting points, it may yet be necessary to check the chopper frequency.
This frequency depends on the position of the GAIN switch: x1: 1 MHz
x10: 200 kHz

The frequency can be checked e.g. on the base (R457) of TS424 in the intermediate amplifier.

The frequency may also be checked using the oscilloscope itself, in the following way:
– Connect the Y_A input to the base of TS424.
– A/OFF/A–B switch to A.
– B/OFF/–B switch to B.

– Y_A input AC/0/DC switch to AC.
– Y_A AMPL. switch to .2 V/div.
– MAIN TIME-BASE switch to .5 μs/div.
– Set both POSITION potentiometers for a distance of six divisions between the traces.
– Adjust the LEVEL potentiometer of the main time-base in order to obtain a stable display (remember this is not a conventional way of operating an oscilloscope).

5. Vertical output amplifier

This unit is provided with four potentiometers for adjusting the d.c. level.

Required instrument:

A d.c. electronic voltmeter, free from earth.

– AC/0/DC switches to 0.
– A/OFF/A–B switch to A.
– B/OFF/–B switch to OFF.
– Connect the voltmeter as indicated in Fig. XI-3 via 10 kΩ resistors between the emittors of TS601 and TS604 (points 1 and 2 in Fig. XI-4).
– Adjust the Y_A POSITION potentiometer until the voltage is 0 V + or –100 mV.

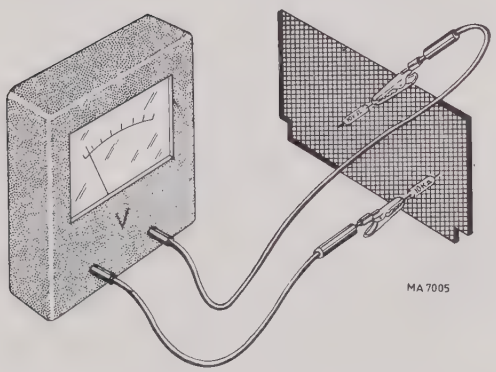


Fig. XI-3. A 10 kΩ resistor fixed on each test pin to avoid parasitic oscillations

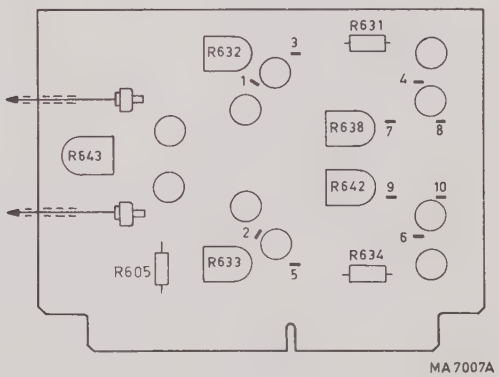


Fig. XI-4. Test points vertical output amplifier

– The voltages across R639 and R641 (points 7-8 and 9-10 respectively in Fig. XI-4) must be 3,1 V + or –200 mV. If necessary, these voltages can be adjusted with R638 and R642 respectively (the voltmeter may here be used without series resistors).
– Connect the voltmeter (as indicated in Fig. XI-3) between the collector of TS606, and the junction of TS608 and TS609 collectors (points 3 and 4 in Fig. XI-4).
Adjust potentiometer R632 LEV. until this voltage is 0 V + or –200 mV (if necessary, change R631).
– Connect the voltmeter (as indicated in Fig. XI-3) between the collector of TS607, and the junction of TS611 and TS612 collectors (points 5 and 6 in Fig. XI-4).
Adjust potentiometer R633 LEV. until this voltage is 0 V + or –200 mV (if necessary, change R634).
– With both Y channel switches in the OFF position the trace must be approximately in the screen centre. If necessary adjust R643.

6. H.F. Square-wave response and rise-time

Optimum h.f. square-wave response and rise-time depend on correct adjustment of the pre-amplifiers and the intermediate amplifier.
In this procedure check that the displayed leading edge top is free from ringing, overshoot and undershoot.
Flat-top error should not exceed 2 % for the A or B channel mode, or 5 % for the A–B or –B mode.
Rise-time must be less than 7 ns.
The alignment of the input attenuators of the pre-amplifiers as well as the main time-base sweep time calibration must be in order (refer to chapters D.1.e. and F.3).
Adjust the main time-base TIME/div. control and the trigger LEVEL control to obtain a suitable display of a square-wave leading edge top. Various settings of the main time-base TIME/div. control may be necessary for optimum viewing results.
Vertical deflection during this procedure is four divisions.

Required instruments:
- Square-wave generator, 100 kHz, rise-time less than 3 ns. Tektronix type 106 square-wave generator recommended.
- Use a 50 ohm in-line cable end termination plugged onto the oscilloscope input.

General settings:
- Main time-base trigger selectors: TRIGG., HF, +.
- X DEFL. switch to MAIN TB.
- GAIN switch to X1.
- Both AC/0/DC switches to AC.

Channel A

- Trigger selector switch to Y_A.

a. H.F. square-wave response

- A/OFF/A–B switch to A.
- B/OFF/–B switch to OFF.
- Apply the (100 kHz, Tr $<$ 3 ns) square-wave signal of 80 mV to the Y_A input.
- Y_A AMPL. switch to 20 mV/div. (cont. control to CAL).
- Centre the display with the Y_A and X POSITION knobs.
- If necessary adjust the following controls or selecting components; note that it is important to adjust the controls in their stated sequence. See Fig. XI-5.

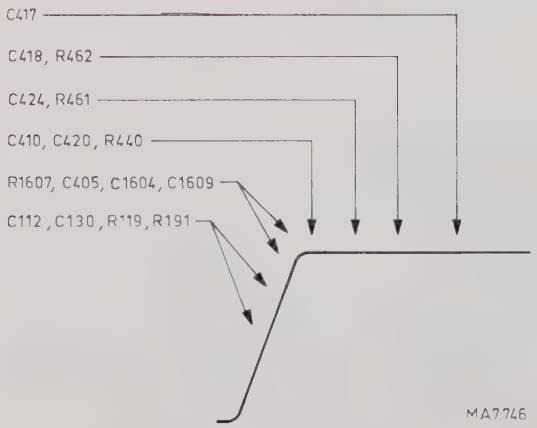


Fig. XI-5. HF Square-wave response channel A

– Y_A AMPL switch to 2 mV/div.
– Y_A input voltage 8 mV.
If necessary adjust R143.
– A/OFF/A–B switch to A–B
– Y_A AMPL switch to 20 mV/div.
– Y_A input voltage 80 mV.
If necessary adjust C1601 or R1602 or change C1600 or C1608.

b. Rise-time

– Check the rise-time, see Fig. XI-6 in position 2–, 5– and 10 mV/div. of the Y_A AMPL switch (reduce the input voltage in these positions to obtain a four-division vertical deflection).

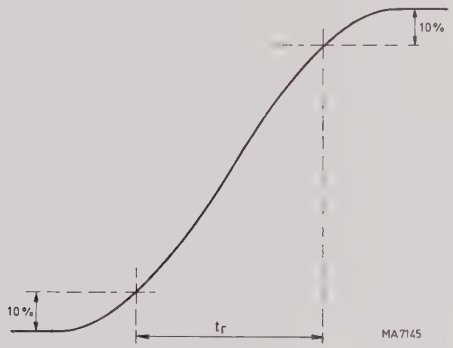


Fig. XI-6. Definition Rise-Time

– If necessary change in the 2 mV/div. position: C123 or R175.

Channel B

– Trigger selector to Y_B.

a. H.F. square wave response

– B/OFF/–B switch to B.
– A/OFF/A–B switch to OFF.
– Apply the (100 kHz, Tr < 3 ns) square-wave signal of 80 mV to the Y_B input.
– Y_B AMPL switch to 20 mV/div. (cont. control to CAL).
– Centre the display with the Y_B and X POSITION knobs.
– If necessary adjust following controls or selecting components.
See Fig. XI-7.

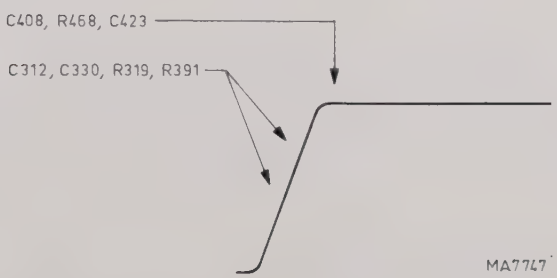


Fig. XI-7. HF Square-wave response channel B

– Y_B AMPL switch to 2 mV/div.
– Y_B input voltage 8 mV.
If necessary adjust R343.
– B/OFF/–B switch to –B.
– Y_B AMPL switch to 20 mV/div.
– Y_B input voltage 80 mV.
If necessary change C404.

b. Rise-time

– Check the rise-time see fig. XI-6 in position 2–, 5–, and 10 mV/div. of the Y_B AMPL switch (reduce the input voltage in these positions to obtain a four division vertical deflection).
– If necessary change in the 2 mV/div. position: C323 or R375.

7. Upper bandwidth limit

Required instruments:

– Constant amplitude sine-wave signal generator, frequency to above 50 MHz.
Tektronix type 191 constant-amplitude signal generator recommended.
– Use a 50 ohm in-line cable end termination plugged onto the oscilloscope input.
The height of the displayed 50 MHz waveform must be at least 0,75 times the height at 100 kHz, for each input (in the 2 mV/div. position of the attenuators it may be 0,7 times).

When the bandwidth is not sufficient the h.f. square-wave response must be readjusted.
When the GAIN switch is in position x10, the bandwidth is limited to 5 MHz.

8. Common mode rejection

With the A/OFF/A–B switch to A–B and the same input signal on both Y inputs (B/OFF/–B switch to B) there must be no vertical deflection.

Required instrument:
A sine-wave generator 100 Hz - 20 MHz.

– A/OFF/A–B switch in position A–B.
– The AMP. continuous controls to CAL.
– Same sine-wave signal on both Y inputs.
– Check the rejection in accordance with the following table:

Setting AMPL. switches	*GAIN switch setting*	*V_{p-p} of input*	*Freq. of input*	*Max. trace height (div.)*	*Rejection factor*
20 mV/div.	x1	800 mV	100 Hz	0,1	400
20 mV/div.	x1	800 mV	2 kHz	0,1	400
20 mV/div.	x1	800 mV	1 MHz	0,2	200
20 mV/div.	x1	800 mV	5 MHz	0,8	50
20 mV/div.	x1	800 mV	20 MHz	2,0 *)	20
20 mV/div.	x10	800 mV	100 Hz	0,1	400
20 mV/div.	x10	800 mV	2 kHz	1,0	400
20 mV/div.	x10	800 mV	1 MHz	4,0	100

*) Correction of this figure is possible with C128/U15; after adjustment of this capacitor, checking of the h.f. response of the vertical amplifiers is necessary.

E. TRIGGERING

The trigger circuit consists of the trigger pick-off stage (unit U25), and the trigger amplifiers on the main time-base (unit U12) and the delayed time-base (unit U11).

The following checks and adjustments are discussed:

1. D.C. levels main time-base R901/U12, R914/U12, R505/U25, R525/U25, R933/U12
2. D.C. levels delayed time-base R701/U11, R714/U11, R733/U11
3. Slope main time-base R957/U12
4. Slope delayed time-base R772/U11

Required instruments:

A d.c. voltmeter
A sine-wave generator (2 kHz)

1. D.C. levels main time-base

The three trigger inputs are adjusted to the same level, with the voltage across R941 as a reference.

– AC/0/DC switches of both Y inputs to 0.
– LEVEL potentiometer of main time-base to mid-position (knob depressed = x1 position).

Channel A:

– Y_A/Y_B/EXT. trigger switch to Y_A.
– Potentiometer R505/U25 to mid-position.
– Check that the voltage across R941/U12 (MP in Fig. XI-8) does not exceed 100 mV (negative with respect to earth), if the trigger switch LF/HF/DC is in the HF position.
If this voltage exceeds 100 mV, replace TS908 (or TS909).
– LF/HF/DC trigger switch to DC.
– Adjust R901/U12 (CH.A) in order to obtain the same voltage across R491/U12, as in position HF or LF of the trigger switch (if necessary change R906/U12).
– GAIN switch to x10.
– Adjust R505/U25 in order to obtain the same voltage across R491/U12.
– Repeat the adjustments of R901/U12 (R906) and R505/U25 until optimum results are obtained.

Channel B:

– Y_A/Y_B EXT. trigger switch to Y_B.
– Potentiometer R525/U25 to mid-position.
– GAIN switch to x1.
– LF/HF/DC trigger switch to DC.
– Adjust R914/U12 (CH.B) in order to obtain the same voltage across R941/U12 as measured at channel A (if necessary change R919/U12).
– GAIN switch to x10.
– Adjust R525/U25 in order to obtain the same voltage across R941.
– Repeat the adjustments of R914 (R919) and R525 until optimum results are obtained.

EXT.

– Y_A/Y_B/EXT. switch to EXT.
– LF/HF/DC switch to DC.
– Adjust R933/U12 in order to obtain the same voltage across R941/U12.

2. DC levels delayed time-base

The three trigger inputs are adjusted to the same level with the voltage across R741/U11 as a reference. First check that the main time-base trigger circuits are properly adjusted; see point **1**.

– AC/0/DC switches of both Y inputs to 0.
– LEVEL potentiometer of the delayed time-base to mid-position (knob depressed = x1 position).

Channel A:

– Set the Y_A/Y_B/EXT. trigger switch of the delayed time-base to Y_A.
– Check that the voltage across R741/U11 (M P in Fig. XI-8) does not exceed 100 mV (negative with respect to earth), if the trigger switch LF/HF/DC is in the HF position.
If this voltage exceeds 100 mV, replace TS708 (or TS709).

– LF/HF/DC trigger switch to DC.
– Adjust R701/U11 (CH.A) in order to obtain the same voltage across R741, as in position HF (if necessary, change R703).

Channel B:

– Y_A/Y_B/EXT. trigger switch to Y_B.
– LF/HF/DC trigger switch to DC.
– Adjust R714/U11 (CH.B) in order to obtain the same voltage across R741/U11 (if necessary, change R717).

EXT.

– Y_A/Y_B/EXT. switch to EXT.
– LF/HF/DC switch to DC.
– Adjust R733/U11 in order to obtain the same voltage across R741/U11.

3. Slope main time-base

– A/OFF/A–B switch to A.
– AC/0/DC switch of Y_A to AC.
– B/OFF/–B switch to OFF.
– Main time-base trigger selector switches to TRIGG., Y_A and LF.
– Apply a 2 kHz sine-wave signal to the Y_A input.
– Adjust the amplitude of the input signal in order to obtain a four division display height.
– Centre the display using the Y_A POSITION potentiometer.
– Main time-base switch to .1 ms/div.
– Set the LEVEL potentiometer of the main time-base for a stable display.
– Set the X POSITION potentiometer so that the beginning of the sine-wave pattern is well visible.
– Adjust the LEVEL potentiometer in conjunction with potentiometer R957/U12 in order to obtain a condition in which the starting point of the sine-wave does not jump when the slope switch +/– is switched between its + and – positions.
– Reduce the input signal amplitude until a display height of 0,5 div. is obtained.
– Adjust the LEVEL potentiometer for a stable display.
– Check that the display remains triggered when the slope switch +/– is switched between its +/– is switched between its + and – positions.
– Make any necessary readjustment to potentiometer R957/U12.
– Eventually can, with still smaller input signals be checked whether the display is stable in both + or – slope switch conditions.
If the display is stable in one polarity condition and running in the other one, potentiometer R957/U12 can be readjusted in order to obtain a stable display for both polarities.
If necessary, adjust the LEVEL potentiometer.

4. Slope delayed time-base

– A/OFF/A–B switch to A.
– AC/0/DC switch of Y_A to AC.
– B/OFF/–B switch to OFF.
– X DEFL. switch to DEL' D TB.
– Main time-base switch to .1 ms/div.
– Main time-base trigger switches to AUTO and EXT. (the main time-base is now free-running).
– Delayed time-base to .1 ms/div.
– Delayed time-base trigger switches to Y_A and LF.
– AFTER DELAY TIME switch to TRIGG.
– DELAY-TIME multiplier to zero.
– Apply a 2 kHz sine-wave signal to the Y_A input.
– Set the Y_A AMPL. switch and the LEVEL potentiometer of the delayed time-base in order to obtain a stable display of four divisions height.
– Adjust the LEVEL potentiometer of the delayed time-base in conjunction with potentiometer R772/U11 in order to obtain a condition in which the starting point of the sine-wave does not jump when the delayed time-base slope switch is switched between its + and – positions.
– Reduce the input signal amplitude until a display height of 0,5 div. is obtained.
– Set the LEVEL potentiometer of the delayed time-base for a stable display.

– Check that the display remains triggered when the trigger slope switch +/– is switched between its + and – positions.
– Make any necessary readjustment to potentiometer R772/U11.
– Eventually can, with still smaller input signals be checked whether the display is stable in both + or – slope conditions.
If the display is stable in one polarity condition and not visible in the other one, potentiometer R772/U11 can be readjusted in order to obtain a stable display for both polarities.
If necessary, adjust the delayed time-base LEVEL potentiometer.

F. MAIN TIME-BASE

Because the accuracy of the time-base sweep is dependent upon the adjustment of the horizontal output amplifier reference has also to be made to chapter **H**.
For the main time-base following adjustments are important:

1. Stability R1036/U12 (STAB.)
2. Gain (horizontal amplifier)
3. Sweep times R1049/U12 (NORM.), R1052/U12 (LOW) C937/U12
4. Linearity (horizontal amplifier)
5. Delayed time-base

Required instrument:
Marker generator

1. Stability

– Both AC/0/DC switches to 0.
– MAIN TIME-BASE switch to 1 ms/div.
– Potentiometer LEVEL fully anti-clockwise.
– AUTO/TRIGG./SINGLE switch to TRIGG.
– Potentiometers R1036/U12 (STAB.) fully clockwise.
– Adjust potentiometer R1036 20° further than the point where the time-base line ceases to be displayed.

2. Gain

Refer to chapter H.2.

3. Sweep times

When the gain of the horizontal amplifier has been adjusted (see chapter H.2.) the sweep times can be adjusted.
– Apply a 10 ms marker signal to the Y_A input.
– MAIN TIME-BASE switch to 10 ms/div. (cont. control to CAL.).
– Adjust R1052/U12 (LOW) so, that the centre eight pulses are presented over exactly eight divisions.
– Marker generator to 1 ms.
– MAIN TIME-BASE switch to 1 ms/div.
– Adjust R1049/U12 (NORM.) so, that the centre eight pulses are presented over exactly eight divisions.
– Marker generator to 0.1 μs.
– MAIN TIME-BASE switch to .1 μs/div.
– Adjust C937/U12 to obtain a display of one pulse per division.

4. Linearity

Refer to chapter H.3.

5. Delayed time-base

If the main time-base has been readjusted also the delayed time-base must be checked and, if necessary, readjusted.

G. DELAYED TIME-BASE

Because the accuracy of the delayed time-base depends upon the adjustment of the horizontal output amplifier, reference has also to be made to chapter **H**.

Following checks and adjustments are important:

1. Stability R807/U11 (STAB.)
2. Gain (horizontal amplifier)
3. Sweep times R819/U11 (NORM.), R824/U11 (LOW), C734/U11
4. Linearity (horizontal amplifier)
5. Delay-time multiplier R1090/U12 (START), R1094/U12 (STOP)
6. Main time-base

Required instrument:
Marker generator

1. Stability

- Both AC/0/DC switches to 0.
- X DEFL. switch to DEL'D TB.
- MAIN TIME-BASE switch to .2 ms/div.
- DELAY TIME multiplier to 0.
- AFTER DELAY TIME switch to TRIGG.
- DELAYED TIME-BASE switch to .1 ms/div.
- LEVEL potentiometer of the delayed time-base fully clockwise.
- Potentiometer R807/U11 (STAB) fully clockwise.
- Adjust potentiometer R807 20° further than the point at which the time-base line ceases to be displayed.
- When the AFTER DELAY TIME switch set to STARTS a time-base line should appear.

2. Gain

Refer to chapter H.2.

3. Sweep times

When the gain of the horizontal amplifier and the sweep times of the main time-base are in order the sweep times can be adjusted.

- Apply a 10 ms marker signal to the Y_A input.
- X DEFL. switch to DEL'D TB.
- DELAYED TIME-BASE switch to 10 ms/div. (cont. control to CAL).
- MAIN TIME-BASE to 20 ms/div. (cont. control to CAL).
- AFTER DELAY TIME switch to STARTS.
- DELAY TIME multiplier to 0.
- Set the LEVEL potentiometer of the main time-base in order to obtain a stable display.
- Adjust the display by means of potentiometer R824/U11 (LOW) so that the centre eight pulses are presented over exactly eight divisions.
- Marker generator to 1 ms.
- DELAYED TIME-BASE switch to 1 ms/div.
- MAIN TIME-BASE switch to 2 ms/div.
- Adjust the display by means of potentiometer R819/U11 (NORM.) so that the centre eight pulses are presented over exactly eight divisions.
- Marker generator to 0,1 μs.
- DELAYED TIME-BASE switch to .1 μs/div.
- MAIN TIME-BASE switch to .2 μs/div.
- Adjust the display by means of C734/U11 so that the centre eight pulses are presented over exactly eight divisions.

4. Linearity

Refer to chapter H.3.

5. Delay-time multiplier

- Apply a 1 kHz sine-wave signal to the Y_A input.
- X DEFL. switch to MAIN TB.

– MAIN TIME-BASE to 1 ms/div. (cont. control to CAL.).
– DELAYED TIME-BASE to 2 μs/div. (cont. control to CAL.).
– AFTER DELAY TIME switch to STARTS.
– Centre the display with the Y_A POSITION potentiometer.
– Set the LEVEL potentiometer of the main time-base so that the sine-wave display starts on the horizontal centre line.
– DELAY-TIME multiplier to 1.00.
– Adjust potentiometer R1090/U12 (START) so that the beginning of the intensified portion of the display starts at the beginning of the second period.
– DELAY-TIME multiplier to 9.00.
– Adjust potentiometer R1094/U12 (STOP) so that the beginning of the intensified portion starts at the beginning of the tenth period.
– Repeat the above procedure in order to obtain optimum results.

6. If necessary, also check the main time-base

H. HORIZONTAL AMPLIFIER

This amplifier consists of the output amplifier U23, and an amplifier stage on the time-base unit (U12). Only for the EXTERN via Y_B mode an additional amplifier is used, located on unit U26b.

The horizontal amplifier is provided with the following checking and adjusting possibilities:

1. D.C. level R1109/U12 (DC)
2. Gain R1122/U12 (x1), R1123/U12 (x5)
3. Linearity C1176, C1178/U23
4. EXT. via Y_B amplifier on unit U26b (R1166, R1159)
5. Bandwidth

The horizontal amplifier must be checked or adjusted if the time-base has been readjusted or the cathode-ray tube has been replaced.

Required instruments:
A d.c. voltmeter, free from earth
A marker generator (1 ms ... 10 ns)

1. D.C. level

– X DEFL. switch to EXTERN via Y_B.
– A/OFF/A–B switch to OFF.
– B/OFF/–B switch to B.
– Using a d.c. voltmeter (free from earth), adjust the channel Y_B POSITION potentiometer, until the potential between the horizontal-deflection plates (side connections red and yellow of the c.r.t.) is zero (max. + or –0,5 V).
– Taking care not to move the setting of the POSITION potentiometer, adjust potentiometer R1109/U12 (D.C.) until the horizontal deflection plates are within + or –1 V with respect to chassis (if necessary, check the d.c. level of the amplifier located on U26b; see point **4**).
– Check that the trace is about centralized on the screen.

2. Gain

Gain adjustment can be effected in different ways.

a. Assuming the time-base circuits being in order, the gain can be adjusted using a marker generator as a reference.
   – X DEFL. switch to MAIN TB.
   – Apply a 1 ms marker signal to the Y input.
   – MAIN TIME-BASE switch to 1 ms/div.
   – X MAGN. switch depressed.
   – Adjust R1122/U12 (x1) in order to obtain a display of one pulse per division.
   – MAIN TIME-BASE switch to 5 ms/div.

– X MAGN. switch to x5 (knob pulled out).
– Adjust R1123/U12 (x5) in order to obtain a display of one pulse per division (if necessary change R1124).

b. Assuming both time-base and the horizontal amplifier have been replaced, the horizontal amplifier could be adjusted with the aid of a calibrated sine-wave voltage applied via the EXT via Y_B socket to the horizontal amplifier on unit U26b.

If necessary, readjust the gain adjustment (R1166) of the amplifier on unit U26b (See point 4).

3. Linearity

– Apply a 10 ns marker signal to the Y_A input,
– MAIN TIME-BASE switch to .05 µs/div. (cont. control to CAL).
– X MAGN switch to x5 (knob pulled out).
– X POSITION potentiometer to mid-position.
– Adjust trimmers C1176 and C1178 so, that the eight central periods are presented over an exact width of eight divisions, and that the periods are as equal as possible.
Use the X POSITION potentiometer over its full range to examine the whole display for any possible deviation (this check does not apply for the first five and the last five periods of the whole trace).

4. EXT. via Y_B

a. Balance

– A/OFF/A–B switch to OFF.
– B/OFF/–B switch to B.
– X DEFL. switch to MAIN TB.
– Adjust the trace to the centre of the screen with the Y_B POSITION knob.
– X DEFL. switch to EXTERN via Y_B.
The dot must now be in the centre of the screen.
If necessary adjust R1159/U26b.

b. Gain

Refer to previous point **2.b.**

5. Bandwidth

– X DEFL. switch to EXT. via Y_B.
– Apply a constant-amplitude sine-wave signal to the Y_B input.
– Check that the horizontal deflection at 5 MHz is not less than 0,7x the deflection at 100 kHz.

I. CALIBRATION UNIT

Check that the square-wave signal present at the CAL. socket has an amplitude of 600 mV ±0,7 % (if necessary adjust with R1263/U9).
Check that the frequency of the square-wave is 2 kHz ±0,7 % (if necessary, adjust with R1256/U9).

J. PM 3250X

1. Introduction

The PM 3250X may be calibrated in the same way as stated in the checking and adjusting section of the basic PM 3250, provided that the PULL FOR TV FRAME and PULL FOR TV LINE switches are both depressed (i.e. sync. separator outputs not coupled). Additional calibration procedures required for the PM 3250X are detailed in the following paragraphs.

2. Sync. separator

– R2116/U43, which serves for adjusting the symmetry of the source and drain signals of TS2103, must be in its mid position.

3. External horizontal input

- Set the X DEFL. switch to EXTERN.
- Set the horizontal attenuator (R20) located at the right-hand side of the cabinet, in the calibrated position (fully clockwise).
- Apply a 2 kHz sine-wave signal of 6 $V_{p\text{-}p}$ to the TRIGG./EXT. X input.
- Adjust R2152//U43 in order to obtain a 6 div. deflection (deflection factor 1 V/div.)
- Now apply a 10 kHz square-wave signal 6 $V_{p\text{-}p}$ to the TRIGG./EXT. X input.
- Connect a saw-tooth signal, which is triggered by the 10 kHz square-wave, to the Y_A input.
- Adjust C2129/U43 (eventually C2122/U43) for optimum square-wave response.

Reference item no. to page no. chapter Checking and Adjusting.

Item	*Page no.*	*Item*	*Page no.*	*Item*	*Page no.*
C108	88	R119	92	R772	96
C112	92	R122	87	R807	98
C123	93	R123	87	R819	98
C128	94	R141	93	R824	98
C130	92	R143	87	R901	95
C308	88	R145	87	R906	95
C312	93	R175	93	R914	95
C323	94	R191	92	R919	95
C330	93	R319	93	R933	95
C405	92	R322	87	R957	96
C408	93	R323	87	R1036	97
C410	92	R341	93	R1049	97
C417	92	R343	87	R1052	97
C418	92	R345	87	R1090	99
C420	92	R375	94	R1094	99
C423	93	R391	93	R1109	99
C424	92	R413	90	R1122	99
C734	98	R418	90	R1123	100
C937	97	R440	92	R1124	100
C1176	100	R443	90	R1159	100
C1178	100	R452	89	R1160	100
C1306	85	R455	90	R1166	100
C1307	85	R461	92	R1208	84
C1403	89	R462	92	R1242	84
C1422	89	R465	91	R1256	100
C1600	93	R468	93	R1263	100
C1601	93	R475	89	R1308	85
C1604	92	R486	90	R1321	85
C1608	93	R491	90	R1325	85
C1609	92	R495	90	R1327	85
C2122	101	R505	95	R1328	85
C2129	101	R525	95	R1337	85
		R631	91	R1339	85
		R632	91	R1341	85
		R633	91	R1343	85
		R634	91	R1344	85
		R638	91	R1346	85
		R642	91	R1406	89
		R643	91	R1419	89
		R701	96	R1602	93
		R703	96	R1607	92
		R714	96	R1615	90
		R717	96	R1623	89
		R733	96	R2116	100
				R2152	101

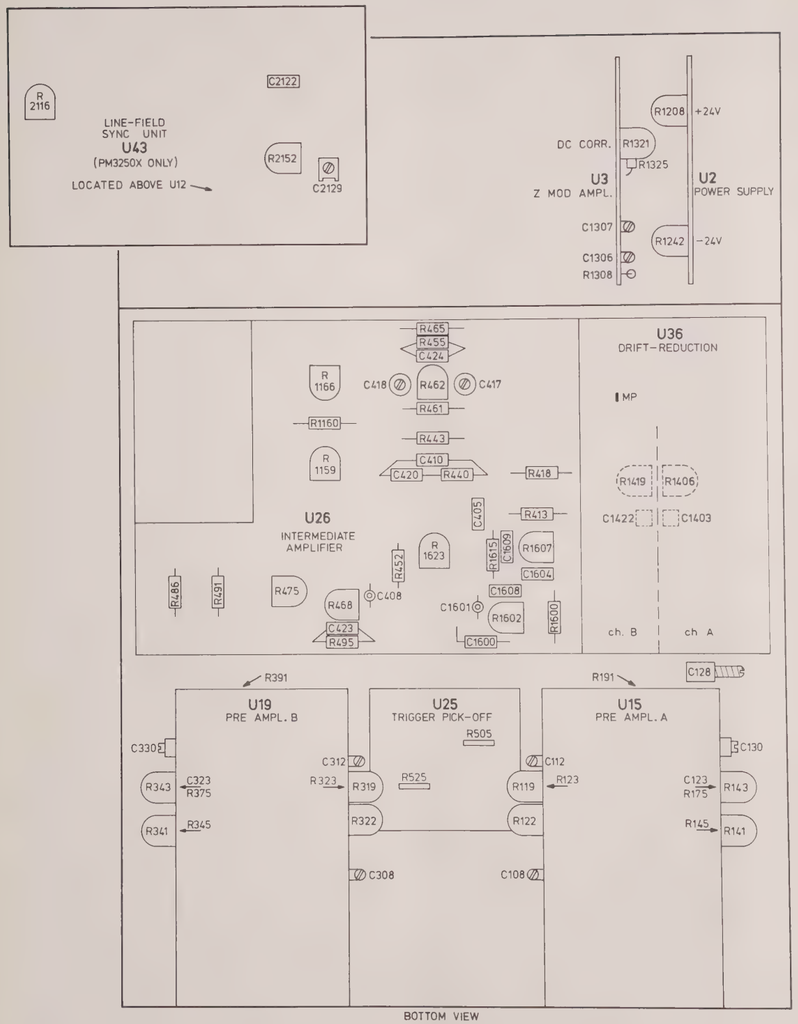


Fig. XI-8. Location various adjustment points

XII. Information for assistance in fault finding

A. VOLTAGE LEVELS

The d.c. levels on the most important points of the circuits have been indicated on the circuit diagrams.
These values may slightly differ per instrument.
The measurements have been carried out under the following conditions:
- Switch "AUTO/TRIGG/SINGLE" in position "AUTO".
- Switch "X DEFL" in position "MAIN TB".
- Switches "AC-0-DC" in position "0".
- Switch "GAIN" in position "x1".
- Potentiometers "Y POSITION" in the centre position.
- Switch "TIME/div" of the main time-base in position "1 ms/div.".
- For measurements in channel A; switch "B/OFF/–B" in position "OFF" and switch "A/OFF/A–B" in position "A".
- For measurements in channel B: switch "B/OFF/–B" in position "B" and switch "A/OFF/A–B" in position "OFF".

B. WAVEFORMS

In some circuit diagrams voltage waveforms are shown. The various switch positions are given in these diagrams.

C. REPAIR HINTS

1. **Fault: there is only trace A visible**
   - Check that the d.c. level on the output of the pre-amplifier A (thus on the cursor of R14) is 0 V.
     If not, change the connections between the pre-amplifiers and the drift reduction circuits. (Thus connect R127 to R1439, R327 to R1417, R134 to R1423, R334 to R1401).
   - If there is now only trace B visible, then the drift reduction circuit of channel A is defective.
   - If there is now only trace A visible, then the pre-amplifier of channel A is defective.

2. **Fault: there is only trace B visible**
   - Check the pre-amplifier and the drift reduction circuit of channel B according to point C.1.

3. **Fault: the pre-amplifier A is defective**
   - Remove the connection between R127 and R1417.
   - Check that the d.c. levels on the different points of pre-amplifier A have the values indicated on the circuit diagram.

4. **Fault: the pre-amplifier B is defective**
   - Remove the connection between R327 and R1439.
   - Check that the d.c. levels on the different points of pre-amplifier B have the values indicated on the circuit diagram.

5. **Fault: the drift reduction circuit is defective**
   - Check the square-wave voltage of the multivibrator TS1409 - TS1411 (on collector of TS1409: +5/–10 V 1700 Hz)
   - Check whether the square-wave signal is present on the input and output of the operational amplifiers IC1401 and IC1402).

6. **Fault: no traces visible**
   - Remove final transistors TS422 and TS424 of the intermediate amplifier.
     A horizontal line should now appear on the centre of the screen. If not, check the delay line and the vertical output amplifier.

D. MODIFICATIONS

During manufacturing following circuit-modifications have been carried out:

1. To avoid the possibility of oscillation if the power supply is short-circuited, R1275 (750 ohm CR16 5 %) in series with C1240 (10 nf 40 V) have been connected between the collector of TS1217 and earth.
2. C878 on the main time-base switch has been modified to 120 pF (for some units the hold-off time was too short resulting in an oscillation phenomenon on the trace).
3. Z-diode GR1310/U4 has been modified to type BZX61/C47 for two reasons:
   – Recent CRT's need somewhat higher grid cut-off voltage.
   – To withstand the discharge current of C1312 when B1301 is ignited (when switching-on).
4. To avoid overheating of TS728 and TS941 in the time-base units, R829 and R1064 have been changed to 8200 ohm (0,5 W 5 %).

Above modifications have been worked already in the circuit diagrams of this manual.
We advise to incorporate these modifications on apparatuses as they come to hand.

E. NOTES

In case of a defect it is always possible to apply to the world wide Philips Service Organisation.
When the instrument is to be sent to a Philips Service Workshop for repair, the following points should be observed:

– Attach a label with your name and address to the instrument.
– Give a complete description of the faults found.
– Use the original packing or, if this is no longer available, carefully pack the instrument in a wooden crate or box.
– Send the instrument to the address obtained after consultation with the local Philips Organisation.

XIII. List of parts

MECHANICAL PARTS

Item	*Code number*	*Description*
Front side photograph Fig. XIII-1		
1	5322 413 30164	Knob of SK13
2	5322 413 30346	Knob Ø 14,5 - Ø 6 flat-face shaft (R6, R7)
3	5322 413 30083	Knob Ø 14,5 - Ø 4 (R8, R16, R17)
4	5322 413 90026	Bourns knob, compl. (R4)
5	5322 413 40112	Knob Ø 23 - Ø 6 with white line (SK7, SK11, SK26, SK27)
	5322 413 30085	Knob Ø 14,5 - Ø 4 with red line (R2, R5, R14, R15)
	5322 413 70039	Cap with red line, for Ø 14,5 knobs
6	5322 413 30082	Knob Ø 14,5 - Ø 6 (R1/SK5, R3/SK9, R9/SK19)
2, 3, 6	5322 413 70038	Cap with black line, for Ø 14,5 knobs
7	5322 404 60058	Switch knob with mechanism (SK1...4, SK10, SK20...25)
	5322 404 50592	Clamping bracket for switch lever (SK1...4, SK10, SK20...25)
	5322 502 11235	Screw M 2,5 for clamping bracket
8	5322 404 60057	Switch knob with mechanism (SK15...18)
9	5322 267 10004	BNC socket (BU1...4, BU8)
10	5322 265 30096	Outlet 'Probe Power' (BU5, BU7)
11	5322 268 20021	4 Ø socket ⏚
12	5322 462 10103	Tilting bracket
	5322 462 44067	Tilting bracket hinge block
13	5322 498 54003	Carrying handle
14	5322 381 14042	Light coupler 'Power On' (LA5)
15	5322 455 80054	Text plate PM 3250
	5322 455 84004	Text plate PM 3250X
16	5322 381 10152	Lens 'Magn. On' (LA4)
17	5322 459 40233	Bezel
18	5322 480 30078	Contrast filter, grey
	5322 480 34037	Contrast filter, green
	5322 480 34036	Contrast filter, yellowish-green PM 3250G
19	5322 417 24006	Quick-Fastener compl.
Rear side photograph Fig. XIII-2		
20	5322 462 40253	Rubber strip
21	5322 255 40091	Insulation cover
	5322 255 40072	Mica plate and bushing (56 101)
	5322 255 40085	Transistor socket
22	5322 256 40026	Fuse cartridge
23	5322 462 40252	Rubber foot
24	5322 462 70737	Cover of voltage adaptor
25	5322 267 10004	BNC socket (BU9...BU12)
	5322 462 54021	Shielding cap (rear side BU9, 11, 12)
	5322 506 14001	Special nut for shielding cap 3/8'' (32 NEF)
	5322 290 34022	Soldering lug Ø 10 (BU10, 12)
Top side photograph Fig. XIII-3		
26	5322 320 40032	Coaxial delay line L501 (length approx. 45 cm)
27	5322 320 10064	Coaxial cable (50 cm) with plug (50 Ω)

Item	*Code number*	*Description*
28	5322 492 64079	V-spring, slide switch drive
29	5322 528 20165	Flexible shaft coupling
30	5322 255 10007	Lamp holder (LA4, LA5)
31	5322 255 20022	Lamp holder (LA1, LA2)
	5322 462 44023	Insulation cover of lamp holders (LA1, LA2)
32	5322 320 24001	High tension cable complete with connector
33	5322 219 80158	Delay line (L603) complete (char. imp. 50 Ω; delay time 65 ns)
34	5322 462 30117	Guide part for print panels
35	5322 255 40054	Transistor cooling radiator (TO-5)
36	5322 255 40089	Transistor socket (TO-18) with four contacts*
37	5322 255 40015	Transistor socket (TO-5)
37a	5322 255 44014	Transistor socket 8-pole (TO-71)
38	5322 255 70159	C.r.t. socket
39	5322 267 60023	P.c. connector with double row soldering lugs
40	5322 267 50122	P.c. connector with one row side soldering lugs
41	5322 267 60034	P.c. connector with double row soldering lugs
Service tools		
–	5322 395 50104	Trimming rod for input attenuator capacitors
	5322 263 70035	Extension p.c. board

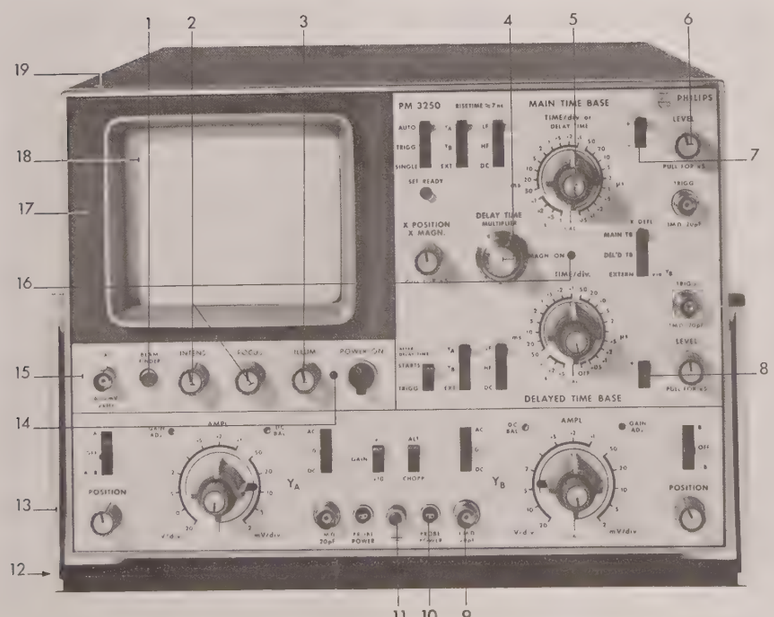


Fig. XIII-1. Front side view

* For replacement of a socket with three contacts, one contact of the replacement socket must be removed.

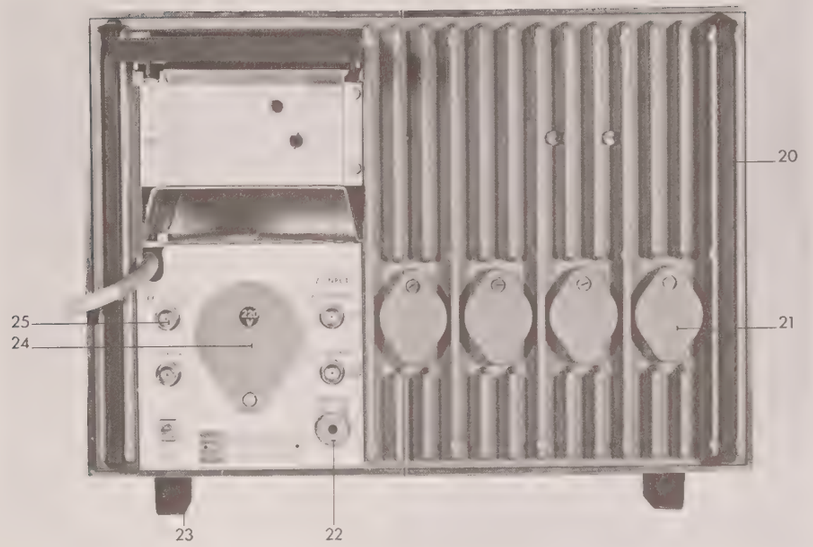


Fig. XIII-2. Rear side view

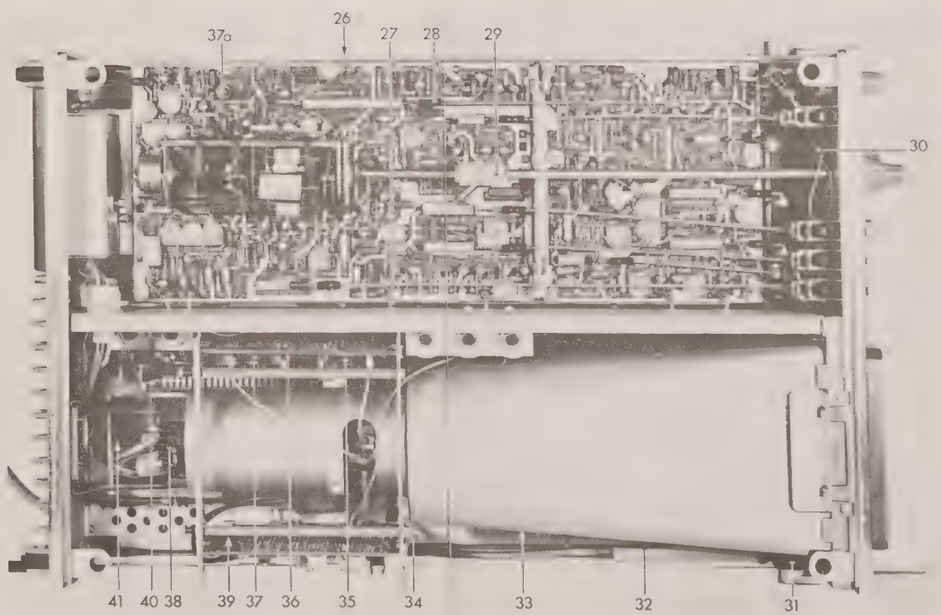


Fig. XIII-3. Top side view

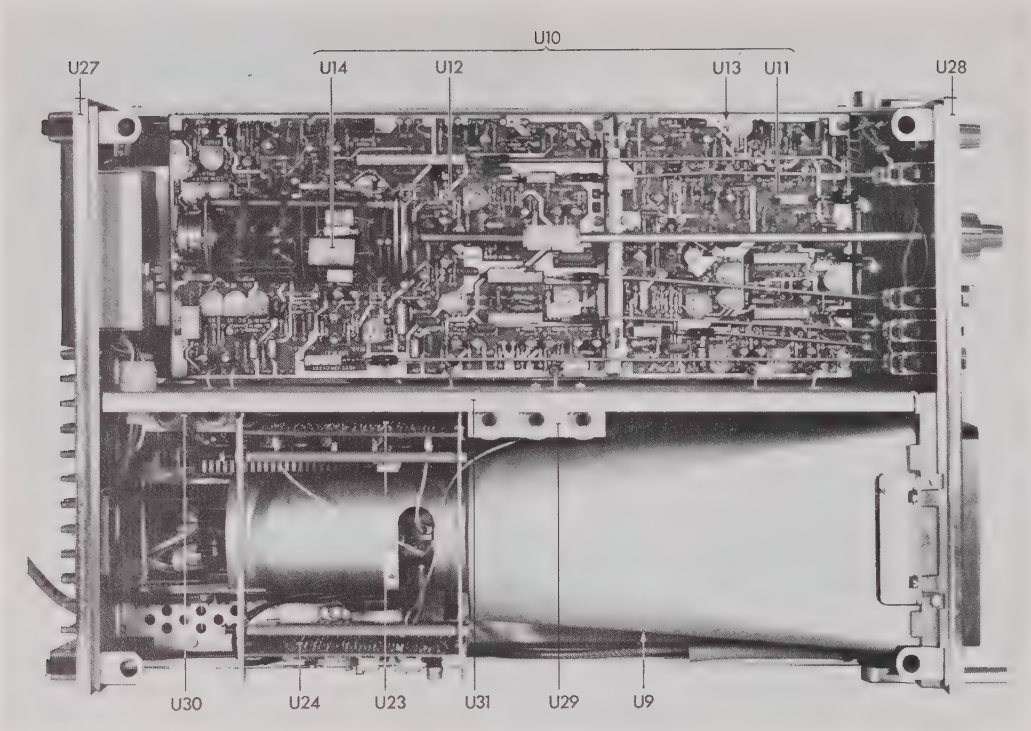


Fig. XIII-4. Top side view

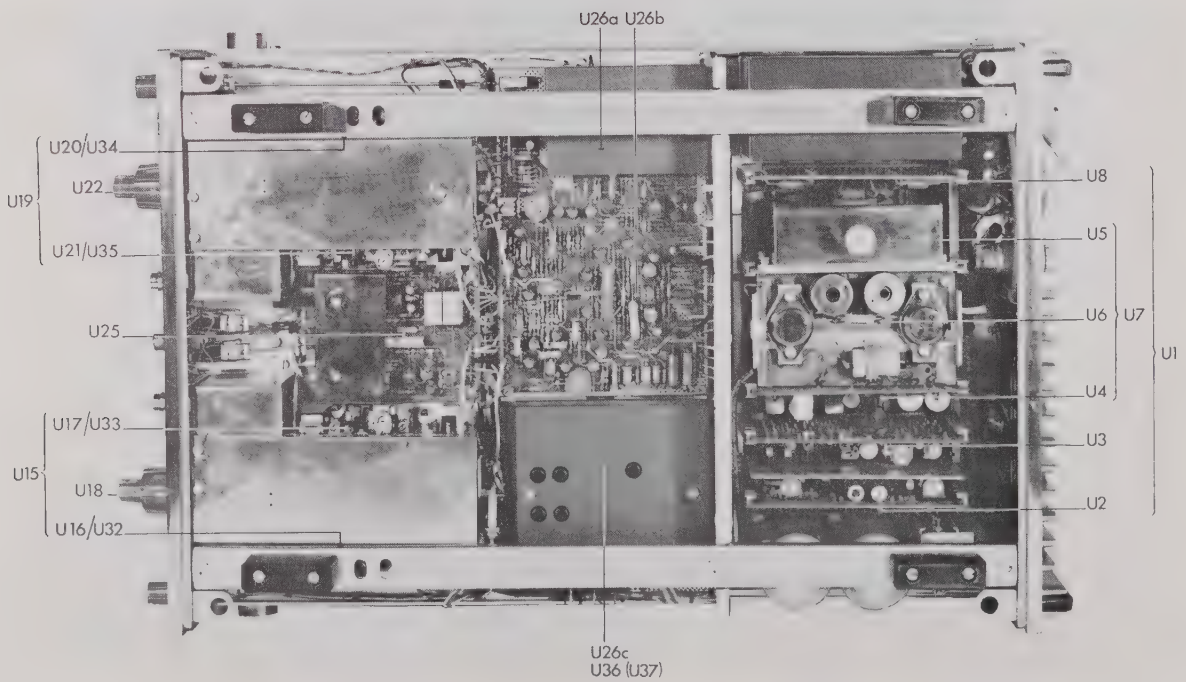


Fig. XIII-5. Bottom side view

COMPLETE UNITS

Item	*Fig.*	*Code number*	*Description*
U2	XIII-5	5322 216 50142	Supply panel
U3	XIII-5	5322 216 54042	Z-amplifier
U7	XIII-5	5322 216 54043	High voltage chopper unit complete
U8	XIII-5	5322 216 50147	Diode panel
U9	XIII-4	5322 216 54045	Calibration unit
U10	XIII-4	5322 216 54047	Time base, compl.
U13	XIII-4	5322 273 80139	D.T.B. switch SK11
U14	XIII-4	5322 273 80141	M.T.B. switch SK7
U15	XIII-5	5322 218 64017	Attenuator A compl.
U19	XIII-5	5322 218 64018	Attenuator B compl.
U23	XIII-4	5322 216 54064	Horizontal output amplifier
U24	XIII-4	5322 216 54065	Vertical output amplifier
U25	XIII-5	5322 216 54066	Trigger pick-off stage
U26a, b	XIII-5	5322 216 54067	Intermediate amplifier
U36	XIII-5	5322 216 54068	Drift reduction circuit
U37	XIII-5	5322 218 64019	Modulator unit
U43		5322 216 54062	Line-Field sync. unit (PM 3250X)

PM 3250X

When ordering replacement units U10 (= U11 + U12) or U26a, b for the PM 3250X version, the above-mentioned code numbers must be ordered, but the circuit boards must be modified as described in chapter **IX.L.5.**

SEMI CONDUCTORS

Type	*Ordering code*	*Remarks*
Diodes		
BA148	5322 130 30256	
BAW62	5322 130 30613	
BAX13	5322 130 40182	
BAX16	5322 130 30273	
BY127	5322 130 30259	
BY176	5322 130 30588	
OA95	4822 130 30191	(PM 3250X)
OF319	5322 130 34192	OF319 = BAV45 selected to $J_{forw.}$ less than 10 nA at $V_{forw.}$ = 450 mV ($T_{amb.}$ = 25 °C)
Zener diodes		
BZX48	5322 130 30397	V_Z = 6,45 V
BZX61/C8V2	5322 130 34115	
BZX61/C15	5322 130 34172	
BZX61/C30	5322 130 30743	
BZX61/C47	5322 130 30565	
BZX61/C68	5322 130 30431	
BZY88/C5V1	5322 130 30284	$V_{GR713 + GR714}$ must be equal to $V_{GR912 + GR913}$ (max. difference 0,1 V)
BZY88/C5V6	5322 130 30193	
BZY88/C6V2	5322 130 30766	
BZY88/C7V5	5322 130 30287	
BZY88/C9V1	5322 130 30294	
BZY94/C68	5322 130 30564	

Type	*Ordering code*	*Remarks*
Transistors		
		Outlines
BC107	5322 130 40357	TO-18
BC109	5322 130 40144	TO-18
BC109C	5322 130 40144	TO-18
BC177	4822 130 40522	TO-18
BC178	5322 130 40355	TO-18
BCY56	5322 130 40325	TO-18
BCY71	5322 130 40373	TO-18
BCY87	5322 130 40423	TO-71
BCY88	5322 130 30187	TO-71
BDY20	5322 130 40449	TO-3 — TS1211 and TS1212 must be selected according to Serv. Inform. Cd 670
BF179	5322 130 40661	TO-5
BFW10	5322 130 40443	TO-72 (PM 3250X)
BFW44	5322 130 40672	TO-39
BFW45	5322 130 40652	TO-39
BFX48	5322 130 40208	TO-18
BFY90	5322 130 40493	TO-72
BSV81	5322 130 44041	TO-72
BSX20	5322 130 40417	TO-18
BSX29	5322 130 40205	TO-18
BSX59	5322 130 40124	TO-39
FW5324	5322 130 40142	TO-18
FW5435	5322 130 40186	TO-18
FW5497	5322 130 40673	TO-5
2N1711 [1]	5322 130 40019	TO-39

[1] 2N1711 may be replaced by BSW66 (R1240, if used, must then be 6,8 kΩ).

Integrated circuits			
TAA521	5322 209 80068	TO-99	Equiv. 709C

VARIOUS ELECTRICAL PARTS

Item	*Fig.*	*Code number*	*Description*
Tubes, lamps			
B1301, B1302	XIV-19, 20	5322 131 90021	Gas-filled tube ZA1004
B1303*	XIII-6	5322 131 20013	Cathode ray tube D14-160 GH/09 (medium short persistence type for PM 3250 and PM 3250X)
		5322 131 24016	Cathode ray tube D14-160 GM/09 (long persistence type for PM 3250G)
LA1, LA2	XIII-6	5322 134 40228	Pilot lamp 12828 12 V 1,2 W
LA3	XIII-6	5322 276 10398	Lamp compl. with switch
LA4	XIII-6	5322 134 40003	Pilot lamp 7121D 6 V 0,05 A
LA5	XIII-6	5322 134 40065	Pilot lamp 8108D 24 V 0,05 A

* The cathode ray tube is delivered complete with coils L1301 and L1302.

Item	*Fig.*	*Code number*	*Description*
Fuses			
VL1	XIII-7	4822 253 30021	1 A 'slow blow' (for 200 V, 220 V, 245 V)
VL1	XIII-7	4822 253 30025	2 A 'slow blow' (for 110 V, 125 V)
VL2	XIV-21	4822 252 20001	Thermal fuse (138 °C), located in supply transformer T1201
Transformers			
T501	XIV-7	5322 158 10291	Transformer of blocking oscillator
T1201	XIV-21	5322 146 24006	Power supply transformer
T1202	XIV-21	5322 148 80014	High tension transformer
Switches			
SK1	XIV-16, 17	5322 277 30466	Slide switch
SK2, SK16	XIV-16, 17	5322 277 30468	Slide switch
SK3, SK17	XIV-16, 17	5322 277 30467	Slide switch
SK4, SK15	XIV-16, 17	5322 277 30409	Slide switch
SK18, SK23			
SK6	XIII-6	5322 276 10398	Switch compl. with lamp
SK7	XIV-16	5322 273 80141	Rotary switch, compl.
SK10	XIV-18	5322 277 30469	Slide switch
SK11	XIV-17	5322 273 80139	Rotary switch, compl.
SK13	XIII-6	5322 276 10399	Switch (without button)
SK14	XIII-6	5322 277 10226	Mains switch
SK20, SK25	XIV-8,9	5322 277 30473	Slide switch
SK21, SK24	XIV-3, 4, 5, 6	5322 277 30472	Slide switch
SK22	XIV-8, 9	5322 277 30474	Slide switch
SK28	XIII-21	5322 272 10003	Voltage adaptor
SK32, 33		5322 276 54011	Push button switch assy (PM 3250X)
Above mentioned slide switches are supplied without driving mechanism (see 'Mechnical Parts'), but with nylon fork.			
–	–	5322 492 64079	V-spring (fixing the nylon fork to the drive mechanism)
Coils			
L101, L102, L301, L302 L401, L402	XIV-5, 6, 7	5322 158 10243	R.F. choke 100 μH *
L501	XIV-7	5322 320 40032	Coaxial delay line, length approx. 45 cm
L502, L503	XIV-15	5322 158 10276	R.F. Choke 4,7 μH *
L601, L602	XIV-14	5322 158 10284	R.F. Choke 0,68 μH *
L603	XIV-8, 9	5322 219 80158	Delay line unit, complete 65 ns, char. imp. 50 Ω
L1201, L1202	XIV-21	5322 158 20312	Pot. core choke 0,7 mH 0,1 Ω
L1203, L1204	XIV-21	5322 158 20235	Pot. core choke 50 mH 10 Ω
L1301, L1302	XIV-19, 20	–	Part of c.r.t. assembly
Relays			
RE101 -		5322 280 20007	Reed relay, glass-tube contact only
		5322 281 60125	Reed relay, coil only 12 V, 910 Ω

* Value indicated by standard color code.

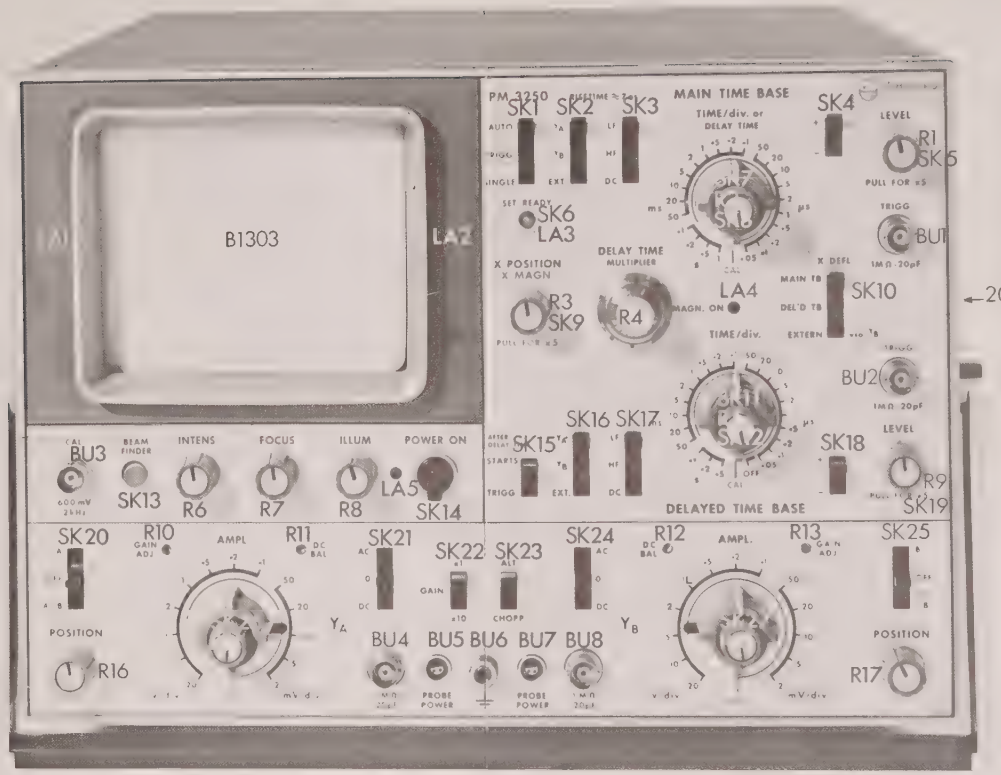


Fig. XIII-6. Front side view

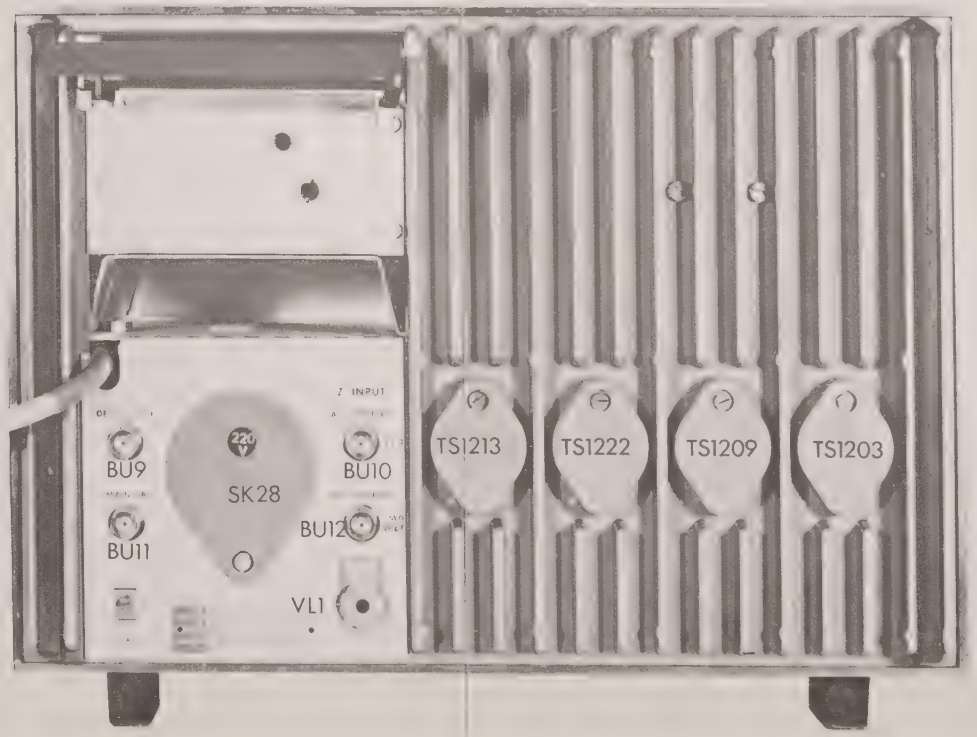


Fig. XIII-7. Rear side view

B. ELECTRICAL — ELEKTRISCH — ELEKTRISCH — ELECTRIQUE — ELECTRICOS

This parts list does not contain multi-purpose and standard parts. These components are indicated in the circuit diagram by means of identification marks. The specification can be derived from the survey below.

Diese Ersatzteilliste enthält keine Universal- und Standard-Teile. Diese sind im jeweiligen Prinzipschaltbild mit Kennzeichnungen versehen. Die Spezifikation kann aus nachstehender Übersicht abgeleitet werden.

In deze stuklijst zijn geen universele en standaardonderdelen opgenomen. Deze componenten zijn in het principeschema met een merkteken aangegeven. De specificatie van deze merktekens is hieronder vermeld.

La présente liste ne contient pas des pièces universelles et standard. Celles-ci ont été repérées dans le schéma de principe. Leurs specifications sont indiquées ci-dessous.

Esta lista de componentes no comprende componentes universales ni standard. Estos componentes están provistos en el esquema de principio de una marca. El significado de estas marcas se indica a continuación.

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,125 W 5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
1 W ≦ 2,2 MΩ, 5%
> 2,2 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,25 W ≦ 1 MΩ, 5%
> 1 MΩ, 10%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
2 W 5%

Carbon resistor E24 series
Kohleschichtwiderstand, Reihe E24
Koolweerstand E24 reeks
Résistance au carbone, série E24
Resistencia de carbón, serie E24
0,5 W ≦ 5 MΩ, 1%
> 5 ≦ 10 MΩ, 2%
> 10 MΩ, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
0,4 – 1,8 W 0,5%

Carbon resistor E12 series
Kohleschichtwiderstand, Reihe E12
Koolweerstand E12 reeks
Résistance au carbone, série E12
Resistencia de carbón, serie E12
0,5 W ≦ 1,5MΩ, 5%
> 1,5MΩ, 10%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
5,5 W ≦ 200 Ω, 10%
> 200 Ω, 5%

Wire-wound resistor
Drahtwiderstand
Draadgewonden weerstand
Résistance bobinée
Resistencia bobinada
10 W 5%

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
500 V

Polyester capacitor
Polyesterkondensator
Polyesterkondensator
Condensateur au polyester
Condensador polyester
400 V

Tubular ceramic capacitor
Rohrkondensator
Keramische kondensator, buistype
Condensateur céramique tubulaire
Condensador cerámico tubular
700 V

Flat-foil polyester capacitor
Miniatur-Polyesterkondensator (flach)
Platte miniatuur polyesterkondensator
Condensateur au polyester, type plat
Condensador polyester, tipo de placas planas
250 V

Ceramic capacitor, "pin-up"
Keramikkondensator "Pin-up" (Perltyp)
Keramische kondensator "Pin-up" type
Condensateur céramique, type perle
Condensador cerámico, versión "colgable"
500 V

Paper capacitor
Papierkondensator
Papierkondensator
Condensateur au papier
Condensador de papel
1000 V

"Microplate" ceramic capacitor
Miniatur-Scheibenkondensator
"Microplate" keramische kondensator
Condensateur céramique "microplate"
Condensador cerámico "microplaca"
30 V

Wire-wound trimmer
Drahttrimmer
Draadgewonden trimmer
Trimmer à fil
Trimmer bobinado

Mica capacitor
Glimmerkondensator
Micakondensator
Condensateur au mica
Condensador de mica
500 V

Tubular ceramic trimmer
Rohrtrimmer
Buisvormige keramische trimmer
Trimmer céramique tubulaire
Trimmer cerámico tubular

For multi-purpose and standard parts, please see PHILIPS' Service Catalogue.
Für die Universal- und Standard-Teile siehe den PHILIPS Service-Katalog.
Voor universele en standaardonderdelen raadplege men de PHILIPS Service Catalogus.
Pour les pièces universelles et standard veuillez consulter le Catalogue Service PHILIPS.
Para piezas universales y standard consulte el Catálogo de Servicio PHILIPS.

POTENTIOMETERS

Item	*Fig.*	*Ordering number*	Ω	%	*W*	*Remarks*
R1, R9	XIII-6	5322 101 64001	22 k		1/4	23 Ø with switch
R2, R5	XIII-6	5322 101 40043	22 k	20	1/4	23 Ø
R3	XIII-6	5322 101 64002	4,7 k		1/4	23 Ø with switch
R4	XIII-6	5322 103 40045	5 k			ten-turn
R6	XIII-6	5322 101 20362	220 k	20	1/4	
R7	XIII-6	5322 101 20363	100 k	20	1/4	23 Ø
R8	XIII-6	5322 101 20323	10 k	20	0,1	16 Ø
R10, R13	XIII-6	5322 101 20358	50		1	
R11, R12	XIII-6	5322 101 24034	50 k		1	
R14, R15	XIII-6	5322 101 20361	200		1	
R16, R17	XIII-6	5322 101 20135	220	20	0,1	16 Ø
R119, R319	XIV-3	5322 100 10155	250			V
R122, R322	XIV-3, 4	5322 100 10127	5 k			V
R141, R341	XIV-3, 4	5322 100 10155	250			V
R143, R343	XIV-3, 4	5322 100 10128	100			V
R462	XIV-7	5322 100 10152	25 k			H
R468	XIV-7	5322 100 10114	5 k			H
R475	XIV-7	5322 100 10149	100			H
R505, R525	XIV-10	5322 100 10156	50 k			V
R632, R633	XIV-6	5322 100 10126	2,5 k			H
R638, R642	XIV-6	5322 100 10124	250			H
R643	XIV-6	5322 100 10151	1 k			H
R701, R714	XIV-12	5322 100 10152	25 k			H
R733	XIV-12	5322 100 10151	1 k			H
R772	XIV-12	5322 100 10125	10 k			H
R807	XIV-12	5322 100 10123	50 k			H
R819, R824	XIV-12	5322 100 10152	25 k			H
R901, R914	XIV-11	5322 100 10152	25 k			H
R933	XIV-11	5322 100 10151	1 k			H
R957	XIV-11	5322 100 10125	10 k			H
R1036	XIV-11	5322 100 10123	50 k			H
R1049, R1052	XIV-11	5322 100 10152	25 k			H
R1090	XIV-11	5322 100 10153	100 k			H
R1094, R1109	XIV-11	5322 100 10123	50 k			H
R1122	XIV-11	5322 100 10125	10 k			H
R1123	XIV-11	5322 100 10137	500			H
R1159	XIV-7	5322 100 10151	1 k			H
R1166	XIV-7	5322 100 10123	50 k			H
R1208, R1242	XIV-15	5322 100 10148	500			V
R1256	XIV-18	5322 100 10153	100 k			H
R1263	XIV-18	5322 100 10154	500 k			H
R1321	XIV-14	5322 101 14023	2,5 k			V
R1327	XIV-15	5322 100 10153	100 k			H
R1328	XIV-15	5322 101 14044	200 k			H
R1339	XIV-14	5322 101 20064	220 k	5	0,125	

V - Mounted vertically on p.c. board
H - Mounted horizontally on p.c. board

Item	*Fig.*	*Ordering number*	Ω	%	*W*	*Remarks*
R1341	XIV-14	5322 101 20112	47 k	5	0,125	
R1343, R1344	XIV-14	5322 103 20091	4,7 k	5	3	
R1346	XIV-14	5322 130 20094	10 k	5	3	
R1406, R1419	XIV-7	5322 100 10123	50 k			H
R1602, R1607	XIV-7	5322 100 10114	5 k			H
R1623	XIV-7	5322 100 10124	250			H
PM 3250X						
R20	XI-8	5322 101 20079	220 k	20	0,1	
R2116	XIV-17	5322 100 10114	5 k		0,5	H
R2152	XIV-17	5322 100 10153	100 k		0,5	H

CAPACITORS

Item	*Ordering number*	*F*	%	*V*	*Remarks*
C26...C29, C226...C229	5322 125 60067	8 p		500	Trimmer
C31, C231	5322 123 10171	1,5 n	5	300	Disc
C32...C36, C232...C236	5322 125 60067	8 p		500	Trimmer
C37, C237	5322 123 10222	390 p		300	Disc
C38, C238	5322 125 60067	8 p		500	Trimmer
C39, C239	5322 125 60068	4 p		500	Trimmer
C41, C42, C241, C242	5322 125 60067	8 p		500	Trimmer
C43, C243	5322 123 10223	68 p	5	300	Disc
C44, C244	5322 125 60067	8 p		500	Trimmer
C45, C245	5322 123 10224	10 p	20	300	Disc
C46, C246	5322 125 60068	4 p		500	Trimmer
C47, C48, C247, C248	5322 125 60067	8 p		500	Trimmer
C49, C249	5322 123 10224	10 p	20	300	Disc
C51, C52, C251, C252	5322 125 60067	8 p		500	Trimmer
C53, C253	5322 125 60068	4 p		500	Trimmer
C54, C254	5322 122 10096*	82 p	1	500	Cer. tubular
C55, C255	5322 125 60067	8 p		500	Trimmer
C56, C256	5322 125 60068	4 p		500	Trimmer
C57, C257	5322 122 10096*	82 p	1	500	Cer. tubular
C58, C258	5322 125 60068	4 p		500	Trimmer
C59,C259	5322 122 10096*	82 p	1	500	Cer. tubular
C60, C260	5322 125 60067	8 p		500	Trimmer
C61, C261	5322 125 60068	4 p		500	Trimmer
C62, C262	5322 122 10096*	82 p	1	500	Cer. tubular
C63, C64, C263, C264	5322 125 60067	8 p		500	Trimmer
C101, C301	5322 121 40145	100 n	20	630	Polyester
C103, C303	5322 122 30006	10	2	63	Cer. plate
C104, C304	5322 122 30033	4,7 p	±1/4 pF	63	Cer. plate
C106, C306	5322 122 30103	22 n	−20 +100	40	Cer. plate
C107, C307	5322 124 20373	47 µ		10 d.c.	Electrolytic

* These capacitors must be selected within a tolerance of 0,5 %.

Item	Ordering number	F	%	V	Remarks
C108, C308	5322 125 50047	3 p		400	Trimmer
C109, C309	5322 122 30103	22 n	−20 +100	40	Cer. plate
C112, C312	4822 125 60027	6 p		400	Trimmer
C114, C314	5322 121 40233	680 n	10	100	Polyester
C116, C316	5322 121 40256	2,2 µ	10	100	Polyester
C117, C317	5322 122 30103	22 n	−20 +100	40	Cer. plate
C118, C318	4822 122 31175	1 k	10	100	Cer. plate
C119, C319	4822 122 30104	1 p	±1/4 pF	63	Cer. plate
C121, C321	5322 122 30045	27 p	2	63	Cer. plate
C122, C322	5322 122 30103	22 n	−20 +100	40	Cer. plate
C124, C324	4822 122 30104	1 p	±1/4 pF	63	Cer. plate
C128	5322 125 64001	12 p		400	Trimmer
C130, C330	5322 125 50048	3 p		400	Trimmer
C131, C331	5322 124 20407	400 µ	−10 +50	25 d.c.	Electrolytic
C132, C332	5322 124 20355	10 µ	−10 +50	25 d.c.	Electrolytic
C133, C333	5322 122 30034	470 p	2	63	Cer. plate
C136, C336	5322 122 30043	10 n	−20 +100	40	Cer. plate
C137, C337	5322 122 30103	22 n	−20 +100	40	Cer. plate
C408	5322 125 60069	6 p		400	Trimmer
C417, C418	4822 125 50061	5,5 p		100	Trimmer
C419, C421	4822 124 20366	25 µ	−10 +50	25 d.c.	Electrolytic
C426, C427	4822 124 20368	33 µ		16 d.c.	Electrolytic
C505	5322 122 30005	8,2 p	±1/4 pF	63	Cer. plate
C506, C507	5322 122 30023	68 p	2	63	Cer. plate
C510	5322 122 30005	8,2 p	±1/4 pF	63	Cer. plate
C513, C514	5322 122 30023	68 p	2	63	Cer. plate
C516, C517	5322 122 30022	22 p	2	63	Cer. plate
C518, C519	5322 122 30016	33 p	2	63	Cer. plate
C524	5322 122 30022	22 p	2	63	Cer. plate
C527	5322 122 30023	68 p	2	63	Cer. plate
C528	5322 122 30034	470 p	2	63	Cer. plate
C600, C605	5322 122 30023	68 p	2	63	Cer. plate
C700, C702	5322 122 30043	10 n	−20 +100	40	Cer. plate
C704, C705	5322 122 30043	10 n	−20 +100	40	Cer. plate
C706	4822 120 10045	4,7 p	±1/2 pF	500	Cer. tubular
C707	4822 120 10056	12 p	5	500	Cer. tubular
C708	5322 121 40145	100 n	10	630	Polyester
C709, C710	5322 124 10152	18 µ	20	15 d.c.	Tantalum
C712	5322 122 34005	330 p	10	100	Cer. plate
C716, C717	5322 122 30021	100 p	2	63	Cer. plate
C719	5322 122 30021	100 p	2	63	Cer. plate
C721	5322 122 30016	33 p	2	63	Cer. plate
C722	5322 122 30021	100 p	2	63	Cer. plate
C727	5322 122 30022	22 p	2	63	Cer. plate
C729	5322 122 30015	82 p	2	63	Cer. plate
C731	5322 122 30116	56 p	2	63	Cer. plate
C732	4822 122 30032	12 p	2	63	Cer. plate
C734	5322 125 50017	65 p		100	Trimmer
C735	5322 122 30045	27 p	2	63	Cer. plate
C738	5322 122 30027	1 n	10	100	Cer. plate
C743, C744	4822 124 20368	33 µ		16 d.c.	Electrolytic
C746	5322 124 20355	10 µ	−10 +50	25 d.c.	Electrolytic
C851	5322 121 50479	160 n	1/2	63	Polystyrene
C852	5322 121 50481	15,9 n	1/2	63	Polystyrene

Item	*Ordering number*	*F*	%	*V*	*Remarks*
C853	5322 123 10225	1,5 n	1/2	125	Mica
C854	5322 123 10226	240 p	1/2	125	Mica
C856	5322 124 14025	18 µ		35 d.c.	Tantalum
C857	4822 120 10063	22 p	5	500	Cer. tubular
C871	5322 124 14025	18 µ		35 d.c.	Tantalum
C872	5322 123 10226	240 p	1/2	125	Mica
C873	5322 123 10225	1,5 n	1/2	125	Mica
C874	5322 121 50481	15,9 n	1/2	63	Polystyrene
C875	4822 120 10063	22 p	5	500	Cer. tubular
C876	5322 121 50479	160 n	1/2	63	Polystyrene
C877	5322 124 10004	10 µ		20 d.c.	Tantalum
C878	4822 120 10076	68 p	5	500	Cer. tubular
C879	4822 120 20107	1 n	−20 +50	500	Cer. tubular
C881	5322 121 40088	10 n	10	250	Polyester
C882	5322 121 40036	100 n	10	250	Polyester
C900, C902	5322 122 30043	10 n	−20 +50	40	Cer. plate
C904, C905	5322 122 30043	10 n	−20 +50	40	Cer. plate
C906	4822 120 10054	10 p	±1/2 pF	500	Cer. tubular
C907	5322 121 40145	100 n	10	630	Polyester
C908	4822 120 10049	6,8 p	±1/2 pF	500	Cer. tubular
C909, C911	5322 124 10152	18 µ	20	15 d.c.	Tantalum
C913	5322 122 34005	330 p	10	100	Cer. plate
C915	5322 122 30016	33 p	2	63	Cer. plate
C916, C917	5322 122 30021	100 p	2	63	Cer. plate
C919, C921	5322 122 30021	100 p	2	63	Cer. plate
C923	5322 122 30027	1 n	10	100	Cer. plate
C924	5322 124 10008	22 µ	20	35 d.c.	Tantalum
C927	5322 122 30022	22 p	2	63	Cer. plate
C928	4822 122 30023	68 p	2	63	Cer. plate
C929	5322 122 30116	56 p	2	63	Cer. plate
C931	5322 122 30015	82 p	2	63	Cer. plate
C932	5322 122 30021	100 p	2	63	Cer. plate
C934	5322 122 30097	15 p	2	63	Cer. plate
C935	5322 122 30045	27 p	2	63	Cer. plate
C937	5322 120 50017	65 p		100	Trimmer
C940	5322 122 30027	1 n	10	100	Cer. plate
C948, C949	4822 124 20368	33 µ		16 d.c.	Electrolytic
C951	5322 124 20355	10 µ	−10 +50	25 d.c.	Electrolytic
C1176, C1178	5322 125 50047	3 p		400	Trimmer
C1200	5322 121 20173	100 n	20	250	
C1201	5322 124 70235	2x5 m par. *)	−10 +50	40 d.c.	Electrolytic
C1203, C1204	5322 124 10108	47 µ	20	35 d.c.	Tantalum
C1205	5322 121 50478	30 n	5	250	Polystyrene
C1206	5322 124 70235	2x5 m par. *)	−10 +50	40 d.c.	Electrolytic
C1207, C1208, C1209	5322 124 20029	25 µ	−10 +30	300 d.c.	Electrolytic
C1210	5322 121 44092	47 n	20	250	
C1211	5322 124 20029	25 µ	−10 +30	300 d.c.	Electrolytic
C1213	5322 124 10108	47 µ	20	35 d.c.	Tantalum
C1214	4822 124 20539	32 µ	−10 +30	150 d.c.	Electrolytic
C1215	5322 121 44092	47 n	20	250	

*) Note: 1 mF = 1000 µF

Item	Ordering number	F	%	V	Remarks
C1216	4822 124 20539	32 µ	−10 +30	150 d.c.	Electrolytic
C1217, C1218	5322 121 40195	33 n	10	1600	Polyester
C1219...C1223	5322 121 30077	500 p	−20 +50	10 k	High tension
C1225	5322 124 10073	6,8 µ	20	35 d.c.	Tantalum
C1226	5322 121 50421	160 n	1	63	Polystyrene
C1228	5322 122 30091	390 p	2	63	Cer. plate
C1229, C1231	5322 122 30103	22 n	−20 +100	40	Cer. plate
C1300	5322 122 30109	1,5 p	±1/4 pF	63	Cer. plate
C1301	5322 122 40068	1,2 p	±1/4 pF	500	Cer. disc
C1302, C1303	5322 124 10153	22 µ	20	15 d.c.	Tantalum
C1304	5322 124 20059	6,4 µ	−10 +30	150 d.c.	Electrolytic
C1306, C1307	5322 125 50047	3 p		400	Trimmer
C1308	5322 124 20059	6,4 µ	−10 +30	150 d.c.	Electrolytic
C1311	5322 121 40326	6,8 n	10	1600	Polyester
C1314, C1316	5322 121 40195	33 n	10	1600	Polyester
C1317	5322 121 40279	68 n	10	630	Polyester
C1318	5322 121 40012	100 n	10	400	Polyester
C1319	5322 121 40195	33 n	10	1600	Polyester
C1320	5322 122 30027	1 n	10	100	Cer. plate
C1321	5322 121 44014	100 n	10	100	Polyester
C1401	4822 122 30032	12 p	2	63	Cer. plate
C1402	4822 122 30022	22 p	2	63	Cer. plate
C1403	5322 125 50049	9 p		500	Trimmer
C1407	5322 124 10005	3,3 µ	20	15 d.c.	Tantalum
C1408	5322 122 30006	10 p	2	63	Cer. plate
C1409	4822 122 30011	2,2 p	±1/4 p	63	Cer. plate
C1416	5322 121 40252	6,8 µ	10	100	Polyester
C1419	4822 122 30032	12 p	2	63	Cer. plate
C1421	4822 122 30022	22 p	2	63	Cer. plate
C1422	5322 125 50049	9 p		500	Trimmer
C1426	5322 124 10005	3,3 µ	20	15 d.c.	Tantalum
C1427	5322 122 30006	10 p	2	63	Cer. plate
C1428	4822 121 30011	2,2 p	±1/4 pF	63	Cer. plate
C1433	5322 121 40252	6,8 µ	10	100	Polyester
C1437	4822 124 20368	33 µ		16 d.c.	Electrolytic
C1438, C1439	5322 124 20355	10 µ		25 d.c.	Electrolytic
C1601	5322 125 60069	6 p		400	Trimmer
PM 3250X					
C2101	5322 124 10008	22 µ		35 d.c.	Tantalum
C2102, C2104	5322 124 10058	2,2 µ		35 d.c.	Tantalum
C2106	5322 124 10018	2,2 µ		20 d.c.	Tantalum
C2109	5322 124 10162	4,7 µ		25 d.c.	Tantalum
C2113	4822 121 40212	330 n	10	400	Polyester
C2114	5322 124 10073	6,8 µ		35 d.c.	Tantalum
C2121	5322 124 10008	22 µ		35 d.c.	Tantalum
C2123	5322 121 40146	0,1 µ	10	400	Polyester
C2124	4822 122 30028	56 p	2	63	Cer. plate
C2127	5322 124 10073	6,8 µ		35 d.c.	Tantalum
C2128	5322 122 30045	27 p	2	63	Cer. plate
C2129	5322 125 50049	10 p		300	Trimmer
C2131	4822 124 20369	47 µ		25 d.c.	Electrolytic
C2132	5322 124 10073	6,8 µ		35 d.c.	Tantalum

RESISTORS

Item	*Ordering number*	Ω	%	*Style*
R26, R226	5322 116 50777	999 k	1/2	
R27, R227	5322 116 50798	898	1/2	MR31C
R28, R228	5322 116 50776	998 k	1/2	
R29, R229	5322 116 50781	1,82 k	1/2	MR31C
R31, R231	5322 116 50775	996 k	1/2	
R32, R232	5322 116 50789	3,61 k	1/2	MR31C
R33, R233	5322 116 50774	991 k	1/2	
R34, R234	5322 116 50801	9,2 k	1/2	MR31C
R36, R236	5322 116 50773	982 k	1/2	
R37, R237	5322 116 54052	18,7 k	1/2	MR31C
R38, R238	5322 116 50772	964 k	1/2	
R39, R239	5322 116 50792	38,8 k	1/2	MR31C
R41, R241	5322 116 50771	910 k	1/2	
R42, R242	5322 116 50244	100 k	1/2	MR39C
R43, R243	5322 116 50769	820 k	1/2	
R44, R244	5322 116 54197	223 k	1/2	MR39C
R46, R246	5322 116 50768	640 k	1/2	
R47, R247	5322 116 54198	600 k	1/2	
R48, R49, R248, R249	5322 116 54155	100 k	1/2	MR31C
R51, R52, R251, R252	5322 116 54155	100 k	1/2	MR31C
R101, R301	5322 111 30273	10 k	5	CR16
R102, R302	5322 111 30396	22	5	CR16
R107, R108, R307, R308	5322 111 30275	15 k	5	CR16
R109, R309	5322 111 30399	33	5	CR16
R111, R311	4822 111 30324	100	5	CR16
R114, R314	4822 111 30324	100	5	CR16
R118, R318	4822 111 30264	2,7 k	5	CR16
R120, R320	5322 111 54199	898 k	1/4	MR58C
R123, R323, R125, R325	5322 116 54378	5,6 M	1	
R126, R326	4822 111 30325	150	5	CR16
R127, R327	4822 111 30324	100	5	CR16
R129, R329	5322 116 50345	665	1/4	MR31C
R131, R331	5322 116 50784	2,67 k	1/4	MR31C
R132, R332	5322 116 50794	4,32 k	1/4	MR31C
R133, R333	5322 116 50788	332	1/4	MR24C
R134, R334	5322 111 54199	898 k	1/4	MR58C
R137, R337	5322 116 50965	1,21 k	1	MR25
R138, R338	5322 111 30074	56	5	CR16
R139, R339	5322 111 30356	43	5	CR16
R140, R340	5322 111 30074	56	5	CR16
R142, R342	5322 111 30074	56	5	CR16
R144, R343	5322 116 50831	806	1/4	MR31C
R148, R348	5322 116 50788	332	1/4	MR24C
R149, R349	4822 111 30324	100	5	CR16
R151, R351	5322 116 50779	1,33 k	1/4	MR31C
R152, R352	5322 116 50831	806	1/4	MR31C
R153, R353	5322 111 30074	56	5	CR16
R154, R354	5322 111 30356	43	5	CR16
R156, R356	5322 116 50965	1,21 k	1	MR25
R157, R357	5322 111 30074	56	5	CR16

Item	*Ordering number*	Ω	%	*Style*
R160, R360	5322 111 30074	56	5	CR16
R163, R363	4822 111 30324	100	5	CR16
R164, R364	4822 111 30324	100	5	CR16
R165, R365	5322 111 30074	56	5	CR16
R167, R367	4822 111 30351	750	5	CR16
R168, R368	5322 111 30288	47 k	5	CR16
R169, R369	5322 111 30289	56 k	5	CR16
R171, R371	5322 111 30288	47 k	5	CR16
R172, R372	4822 111 30327	220	5	CR16
R173, R373	5322 111 30074	56	5	CR16
R174, R374	5322 116 54183	383	1	MR25
R175, R375	—	—	5	CR16
R176, R376	5322 116 50962	825	1	MR25
R179, R379	5322 111 30074	56	5	CR16
R182, R382	4822 111 30327	220	5	CR16
R183, R383	5322 116 50748	10 k	1/4	MR24C
R184, R384	5322 116 50381	1,78 k	1	MR30
R187, R387	4822 111 30324	100	5	CR16
R189, R389	5322 116 50765	909	1	MR30
R409	5322 111 30269	1 k	5	CR16
R411, R419	4822 111 30324	100	5	CR16
R420	5322 111 30074	56	5	CR16
R421, R422	5322 111 30269	1 k	5	CR16
R423	5322 116 50524	3,01 k	1	MR25
R424	5322 111 30074	56	5	CR16
R426	5322 116 50635	1,47 k	1	MR25
R427	5322 111 30347	10	5	CR16
R430	4822 111 30324	100	5	CR16
R432	5322 111 30347	10	5	CR16
R433	5322 116 50635	1,47 k	1	MR25
R434	5322 111 30074	56	5	CR16
R435	4822 111 30324	100	5	CR16
R436	5322 116 50524	3,01 k	1	MR25
R437	5322 116 51056	11 k	1	MR25
R438	5322 116 50979	8,25 k	1	MR25
R439, R441	5322 111 30074	56	5	CR16
R442	5322 116 54171	2,21 k	1	MR25
R445, R447	5322 116 54056	187	1	MR25
R448, R453	5322 116 50669	205	1	MR25
R454	5322 111 30074	56	5	CR16
R456	5322 116 50979	8,25 k	1	MR25
R457	5322 111 30074	56	5	CR16
R458	5322 116 54171	2,21 k	1	MR25
R459, R464	5322 116 54146	2,37 k	1	MR25
R463	5322 116 50518	1,1 k	1	MR25
R466, R467	5322 111 30365	51	5	CR16
R469	5322 116 50636	2,74 k	1	MR25
R471	4822 111 30325	150	5	CR16
R472, R474	5322 116 54202	7,5 k	1	MR25
R473	5322 116 50561	590	1	MR25
R476	4822 111 30325	150	5	CR16
R477	5322 116 50636	2,74 k	1	MR25
R478	5322 116 54171	2,21 k	1	MR25

Item	*Ordering number*	Ω	%	*Style*
R479, R481	5322 116 50967	2,1 k	1	MR25
R482	5322 116 54171	2,21 k	1	MR25
R483	4822 111 30269	1 k	5	CR16
R484, R489	4822 111 30324	100	5	CR16
R488, R490, R492	4822 111 30269	1 k	5	CR16
R493, R494	4822 111 30139	16 k	5	CR16
R495	–	–	5	CR16
R500	4822 111 30303	8,2 k	5	CR16
R501, R502	5322 111 44009	82	5	CR16
R506, R507	5322 111 44009	82	5	CR16
R509	5322 111 30354	12	5	CR16
R520	4822 111 30303	8,2 k	5	CR16
R521, R522	5322 111 44009	82	5	CR16
R526, R527	5322 111 44009	82	5	CR16
R529	5322 111 30354	12	5	CR16
R543, R548	4822 111 30311	3,9 k	5	CR16
R560	5322 116 50788	332	1	MR25
R566	5322 111 44156	510	5	CR16
R574	5322 111 30074	56	5	CR16
R576	4822 111 30273	10 k	5	CR16
R604	5322 116 50978	825	1	MR25
R602, R606	5322 111 30074	56	5	CR16
R607	5322 116 54136	681	1	MR25
R608	5322 111 30401	47	5	CR16
R609	4822 111 30312	4,7 k	5	CR16
R610	5322 111 30347	10	5	CR16
R612	4822 111 30312	4,7 k	5	CR16
R613	5322 111 30401	47	5	CR16
R614	5322 116 54136	681	1	MR25
R615	5322 111 30347	10	5	CR16
R616	5322 116 50978	825	1	MR25
R617, R619	5322 111 30074	56	5	CR16
R623, R626	5322 116 54167	121	1	MR25
R629, R636	5322 116 50965	1,21 k	1	MR25
R639, R641	4822 111 30327	220	5	CR16
R702	5322 111 30401	47	5	CR16
R704	4822 111 30267	1,5 k	5	CR16
R706	5322 111 30399	33	5	CR16
R711	5322 111 44009	82	5	CR16
R716	5322 111 30401	47	5	CR16
R718	4822 111 30267	1,5 k	5	CR16
R719	5322 111 30399	33	5	CR16
R724, R730	5322 111 44009	82	5	CR16
R739, R746	5322 111 44009	82	5	CR16
R749	5322 116 50972	270	2	CR25
R751, R756	5322 111 30399	33	5	CR16
R753	5322 116 54146	2,4 k	2	CR25
R759	5322 116 50095	510	2	CR25
R761	5322 116 50973	2,7 k	2	CR25
R764	5322 111 44009	82	5	CR16
R767	5322 111 30269	1 k	5	CR16
R769	5322 111 44009	82	5	CR16
R771	5322 111 30273	10 k	5	CR16
R778, R780	5322 111 44009	82	5	CR16

Item	*Ordering number*	Ω	%	*Style*
R781	5322 111 30269	1 k	5	CR16
R784, R786	5322 111 30347	10	5	CR16
R788	5322 111 30399	33	5	CR16
R789	5322 116 54146	2,4 k	2	CR25
R791	5322 111 44009	82	5	CR16
R813	4822 111 30311	3,9 k	5	CR16
R814	5322 111 30137	13 k	5	CR16
R816	5322 111 30399	33	5	CR16
R821	5322 111 30278	27 k	5	CR16
R822	5322 111 30393	6,2 k	5	CR16
R825	5322 116 34009	NTC resistor 4,7 kohm (25 °C)		
R826	4822 111 30303	8,2 k	5	CR16
R828	5322 111 30399	33	5	CR16
R830	4822 111 30311	3,9 k	5	CR16
R831	5322 111 30401	47	5	CR16
R832, R833	5322 111 30399	33	5	CR16
R835	5322 111 30137	13 k	5	CR16
R836	5322 111 30279	33 k	5	CR16
R851	5322 116 54201	30 k	0,1	MR39C
R852	5322 116 50663	15 k	1/4	MR39C
R853	5322 116 54202	7,5 k	1/4	MR39C
R854	5322 116 50807	3,74 k	1/4	MR39C
R856	5322 116 54202	7,5 k	1/4	MR39C
R857	5322 116 50663	15 k	1/4	MR39C
R858	5322 116 54203	75 k	1/4	MR39C
R859	5322 116 50113	150 k	1/4	MR39C
R861	5322 116 50811	300 k	0,1	MR39C
R862	5322 116 50815	741 k	1/4	MR58C
R871	5322 116 50814	732 k	1/4	MR58C
R872	5322 116 54203	75 k	1/4	MR39C
R873	5322 116 50113	150 k	1/4	MR39C
R874	5322 116 50811	300 k	1/4	MR39C
R876, R877	5322 116 50815	741 k	1/4	MR58C
R878	5322 116 50807	3,74 k	1/4	MR39C
R879	5322 116 54202	7,5 k	1/4	MR39C
R881	5322 116 50663	15 k	1/4	MR39C
R882	5322 116 54202	7,5 k	1/4	MR39C
R883	5322 116 50663	15 k	1/4	MR39C
R884	5322 116 54201	30 k	0,1	MR39C
R902	5322 111 30399	33	5	CR16
R904	5322 111 30401	47	5	CR16
R907	4822 111 30267	1,5 k	5	CR16
R911	5322 111 44009	82	5	CR16
R916	5322 111 30399	33	5	CR16
R918	5322 111 30401	47	5	CR16
R921	4822 111 30267	1,5 k	5	CR16
R924, R930	5322 111 44009	82	5	CR16
R939, R944	5322 111 44009	82	5	CR16
R948	5322 111 44009	82	5	CR16
R951	5322 111 30269	1 k	5	CR16
R956	5322 111 30273	10 k	5	CR16
R958, R964	5322 111 44009	82	5	CR16
R967	5322 111 30269	1 k	5	CR16
R968, R969	5322 111 30347	10	5	CR16

Item	*Ordering number*	Ω	%	*Style*
R972	5322 111 44009	82	5	CR16
R978	4822 111 30324	100	5	CR16
R981, R982, R983	5322 111 30269	1 k	5	CR16
R984	5322 111 30347	10	5	CR16
R986	5322 111 30269	1 k	5	CR16
R989	5322 116 54146	2,4 k	2	CR25
R992, R998	5322 111 30399	33	5	CR16
R993	5322 116 50482	33 k	2	CR25
R994	5322 116 50973	2,7 k	2	CR25
R996	5322 116 54224	620	2	CR25
R997	5322 116 54011	5,6 k	2	CR25
R999	5322 116 51056	11 k	2	CR25
R1001	5322 116 50972	270	2	CR25
R1003	5322 116 50664	2 k	2	CR25
R1004	5322 111 44009	82	5	CR16
R1005, R1006	4822 111 30311	3,9 k	5	CR16
R1007	5322 111 30399	33	5	CR16
R1008	5322 116 50748	10 k	2	CR25
R1010, R1012	5322 111 30137	13 k	5	CR16
R1021	5322 111 30269	1 k	5	CR16
R1028, R1031	5322 111 30399	33	5	CR16
R1042	4822 111 30331	470	5	CR16
R1043	5322 111 44009	82	5	CR16
R1044	5322 111 44011	1,8 k	5	CR16
R1051	5322 111 30278	27 k	5	CR16
R1053	5322 111 30393	6,2 k	5	CR16
R1054	4822 111 30303	8,2 k	5	CR16
R1056	5322 116 34009	NTC resistor 4,7 kohm (25 °C)		
R1058	5322 111 30399	33	5	CR16
R1061	5322 111 30401	47	5	CR16
R1062	5322 111 30399	33	5	CR16
R1063	4822 111 30323	270	5	CR16
R1066	5322 111 30279	33 k	5	CR16
R1071	5322 111 30399	33	5	CR16
R1074	5322 111 30069	39	5	CR16
R1076	5322 111 30399	33	5	CR16
R1078	5322 111 44009	82	5	CR16
R1079	4822 111 30264	2,7 k	5	CR16
R1080	4822 111 30303	8,2 k	5	CR16
R1081	4822 111 30312	4,7 k	5	CR16
R1083	5322 111 44009	82	5	CR16
R1084	5322 111 30269	1 k	5	CR16
R1085	5322 111 30329	390	5	CR16
R1087	5322 111 44009	82	5	CR16
R1091	5322 111 30296	100 k	5	CR16
R1095	5322 111 30289	56 k	5	CR16
R1098	4822 111 30312	4,7 k	5	CR16
R1103	5322 111 44009	82	5	CR16
R1108	5322 111 30279	33 k	5	CR16
R1124	—	—	5	CR16
R1128	5322 111 30268	1,2 k	5	CR16
R1129	5322 111 44009	82	5	CR16
R1150	5322 111 30074	56	5	CR16
R1153, R1155	5322 116 50175	649	1	MR25

Item	*Ordering number*	Ω	%	*Style*
R1157, R1158	4822 111 30311	3,9 k	5	CR16
R1161	5322 116 54171	2,21 k	1	MR25
R1162	5322 111 30074	56	5	CR16
R1163	5322 116 54171	2,21 k	1	MR25
R1164	5322 116 50728	1,87 k	1	MR25
R1165, R1170	4822 116 40007	PTC resistor 50 ± 15 ohm (25 °C)		
R1169	5322 111 30074	56	1	CR16
R1171, R1172	5322 116 54171	2,21 k	1	MR25
R1173	5322 116 50728	1,87 k	1	MR25
R1176	5322 111 44009	82	5	CR16
R1179, R1180	5322 116 54204	22,6 k	1	MR39C
R1181	5322 116 50558	18,7 k	1	MR25
R1182, R1183	5322 111 44009	82	5	CR16
R1186	5322 116 50791	3,83 k	1	MR25
R1187, R1188	5322 116 54204	22,6 k	1	MR39C
R1189, R1190	5322 111 44009	82	5	CR16
R1192	5322 111 44009	82	5	CR16
R1201	5322 113 60022	0,47	10	2W; WW
R1207	5322 116 50675	2,26 k	1	MR25
R1209	5322 116 50636	2,74 k	1	MR25
R1215	4822 111 30339	1	5	CR37
R1217	5322 116 50515	1,78 k	1	MR25
R1218	5322 116 50791	3,83 k	1	MR25
R1234	4822 113 60028	2,2	10	2W; WW
R1241	5322 116 50675	2,26 k	1	MR25
R1243	5322 116 50636	2,74 k	1	MR25
R1246, R1247	5322 116 50515	1,78 k	1	MR25
R1250	5322 111 50345	8,2 M	5	1W
R1253	5322 115 90082	65	± 1 ohm	Cu WW
R1254	5322 116 50544	866	1/4	MR39E
R1259	5322 116 50806	3,01 k	1/4	MR39E
R1261	5322 116 54205	7,68 k	1/4	MR39E
R1264	5322 116 34011	NTC resistor 33 ohm (25 °C)		
R1265	5322 116 50472	1,87 k	1/4	MR39E
R1266	5322 116 50804	1,21 k	1/4	MR39E
R1267	5322 116 50268	100	1/4	MR39E
R1268	5322 116 50806	3,01 k	1/4	MR39E
R1269	5322 111 30399	33	5	CR16
R1271	5322 116 54206	43,8 k	1/4	MR39E
R1272	5322 111 30326	180	5	CR16
R1275	5322 110 60104	750	5	CR16
R1311	5322 116 50818	44,2	1	MR25
R1312	5322 116 50788	332	1	MR25
R1317	4822 111 30324	100	5	CR16
R1329	5322 116 50817	51,1	1	MR81D
R1336	4822 111 30327	220	5	CR16
R1401	5322 111 30277	22 k	5	CR16
R1402	5322 111 30269	1 k	5	CR16
R1403	5322 116 54003	22,1 k	1	MR25
R1404, R1407	5322 111 30296	100 k	5	CR16
R1409	4822 111 30267	1,5 k	5	CR16
R1411	4822 111 30309	560	5	CR16
R1413	4822 111 30265	2,2 k	5	CR16
R1414, R1416	5322 111 30296	100 k	5	CR16

Item	*Ordering number*	Ω		%	*Style*	
R1418	4822 111 30263	3,3	k	5	CR16	
R1422	5322 111 30296	100	k	5	CR16	
R1423	5322 111 30277	22	k	5	CR16	
R1424	5322 111 30269	1	k	5	CR16	
R1426	5322 116 54003	22	k	1	MR25	
R1427	5322 111 30296	100	k	5	CR16	
R1431	4822 111 30309	560		5	CR16	
R1433	5322 111 30277	22	k	5	CR16	
R1434	4822 111 30267	1,5	k	5	CR16	
R1436	4822 111 30265	2,2	k	5	CR16	
R1437, R1438	5322 111 30296	100	k	5	CR16	
R1441	4822 111 30263	3,3	k	5	CR16	
R1443, R1446	5322 116 54011	5,62	k	1	MR25	
R1448	5322 116 54171	2,21	k	1	MR25	
R1449	4822 111 30303	8,2	k	5	CR16	
R1451, R1452	5322 116 50474	42,2	k	1	MR25	
R1453	4822 111 30303	8,2	k	5	CR16	
R1454	5322 116 54171	2,21	k	1	MR25	
R1601	4822 111 30325	150		5	CR16	
R1603	5322 116 54182	261		1	MR25	
R1604	5322 111 30281	39	k	5	CR16	
R1606, R1611, R1614	5322 116 54182	261		1	MR25	
R1616	4822 111 30325	150		5	CR16	
R1621	4822 111 30325	150		5	CR16	
R1622	5322 111 30273	10	k	5	CR16	
PM 3250X						
R1124	5322 116 50554	750		1	MR25	
R2102, R2103	5322 111 30296	100	k	5	CR16	
R2104	5322 111 30304	150	k	5	CR16	
R2107	5322 111 30275	15	k	5	CR16	
R2108	5322 111 30296	100	k	5	CR16	
R2109	5322 111 30273	10	k	5	CR16	
R2111	5322 111 30277	22	k	5	CR16	
R2112	5322 111 44144	11	k	5	CR16	
R2117	5322 111 30376	100	M	5	0,125 W	Allen Bradley
R2118	5322 111 30305	36	k	5	CR16	
R2119	4822 111 30312	4,7	k	5	CR16	
R2121, R2122	5322 111 30273	10	k	5	CR16	
R2123	5322 111 30304	150	k	5	CR16	
R2124	4822 111 30333	1	M	5	CR16	
R2126	5322 111 30281	39	k	5	CR16	
R2127	5322 111 30273	10	k	5	CR16	
R2128	5322 111 30378	200		5	CR16	
R2129	5322 111 30296	100	k	5	CR16	
R2131	4822 111 30263	3,3	k	5	CR16	
R2132	5322 111 30296	100	k	5	CR16	
R2133	4822 111 30328	330		5	CR16	
R2134	4822 111 30333	1	M	10	CR16	
R2136	5322 111 34091	30	k	5	CR16	
R2137	5322 111 30124	4,3	k	5	CR16	
R2138	4822 111 30267	1,5	k	5	CR16	

Item	*Ordering number*	Ω		%	*Style*
R2139	5322 111 30265	2,2	k	5	CR16
R2141	5322 111 30296	100	k	5	CR16
R2142	4822 111 30313	5,6	k	5	CR16
R2143	5322 111 30269	1	k	5	CR16
R2144	5322 111 30277	22	k	5	CR16
R2146	5322 111 44143	51	k	5	CR16
R2147	5322 116 50458	7,87	k	1	MR25
R2148	5322 116 54047	787		1	MR25
R2151	5322 111 44009	82		5	CR16
R2153	5322 116 50414	2,87	k	1	MR25
R2154	5322 116 50908	23,7	k	1	MR25
R2156	5322 116 50579	3,16	k	1	MR25
R2157	5322 111 30293	180	k	5	CR16
R2158	5322 111 30306	75	k	5	CR16
R2159	5322 111 30288	47	k	5	CR16
R2161	5322 111 30289	56	k	5	CR16
R2162	5322 111 30275	15	k	5	CR16
R2163	5322 111 30307	91	k	5	CR16
R2164	4822 111 30333	1	M	10	CR16
R2167, R2168	5322 111 30296	100	k	5	CR16
R2169	5322 111 30273	10	k	5	CR16
R2171	5322 111 30277	22	k	5	CR16
R2172	4822 111 30263	3,3	k	5	CR16
R2173	5322 111 30258	390	k	10	CR16
R2176	4822 111 30324	100		5	CR16
R2178	5322 111 44144	11	k	5	CR16

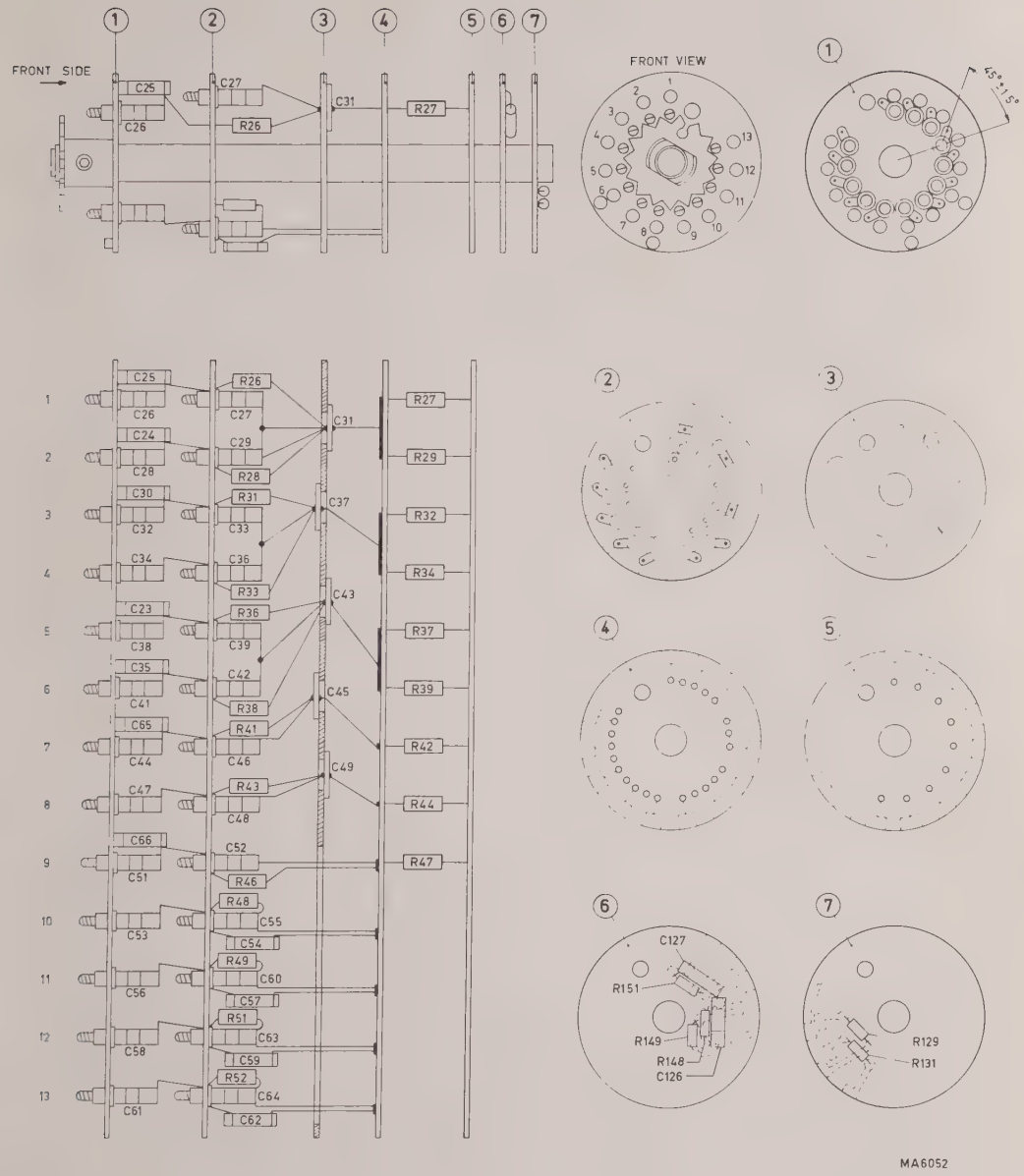


Fig. XIV-1a. Component location

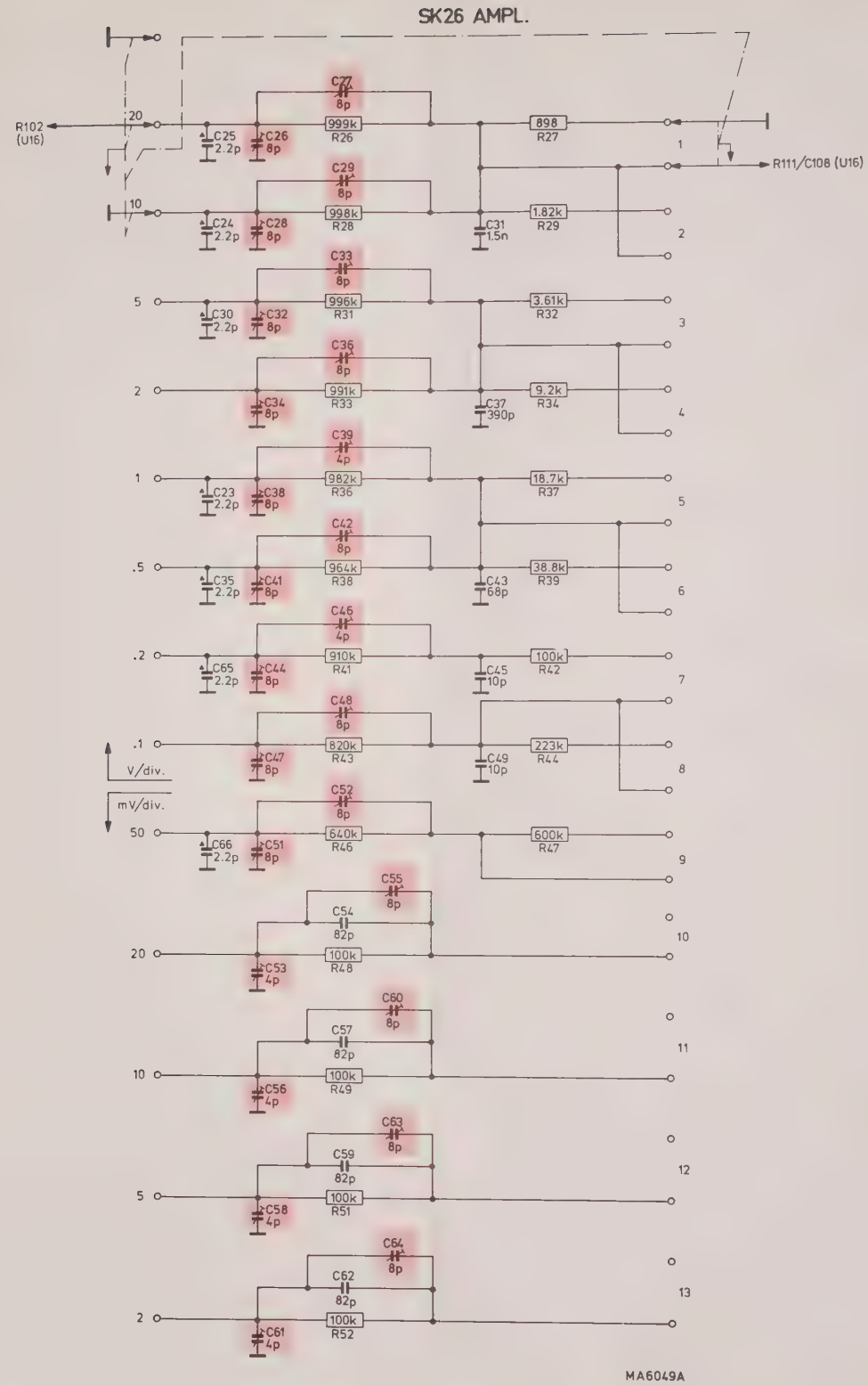


Fig. XIV-1. Circuit diagram

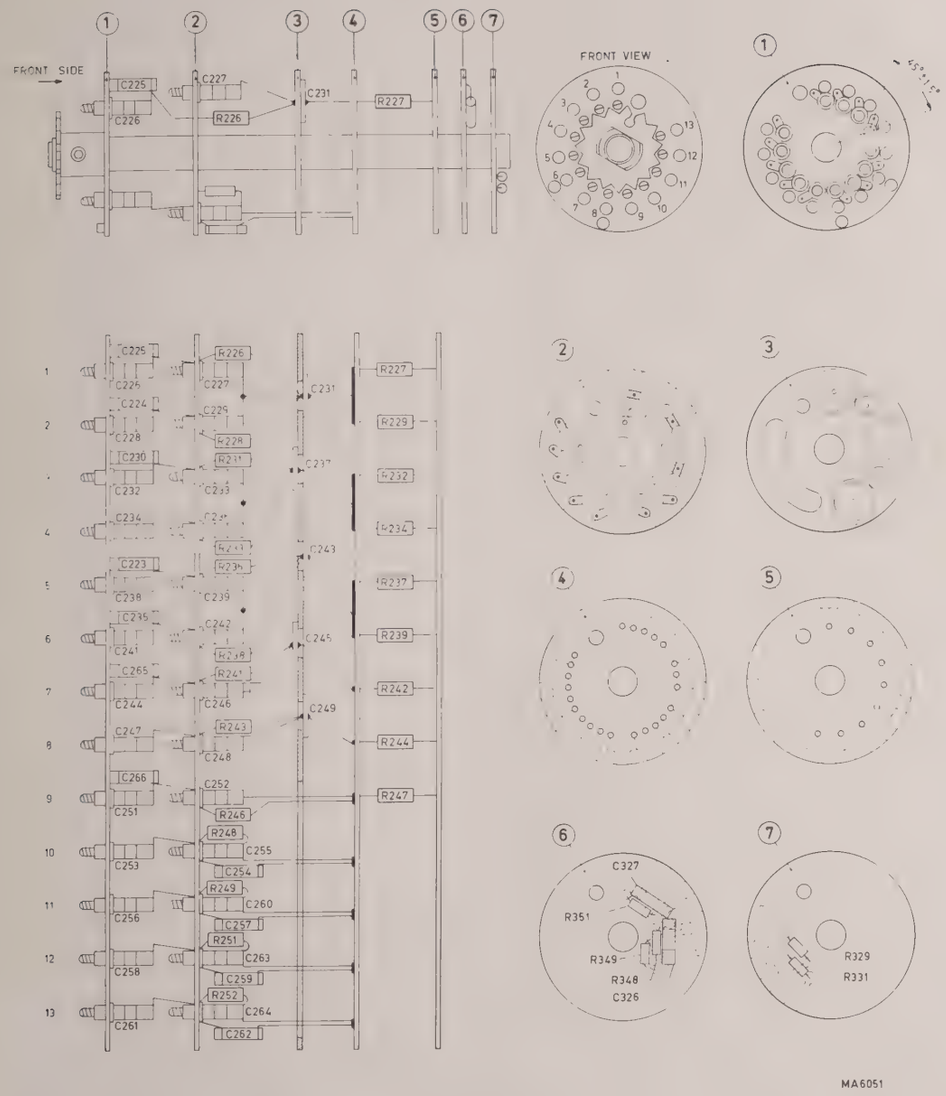


Fig. XIV-2a. Component location

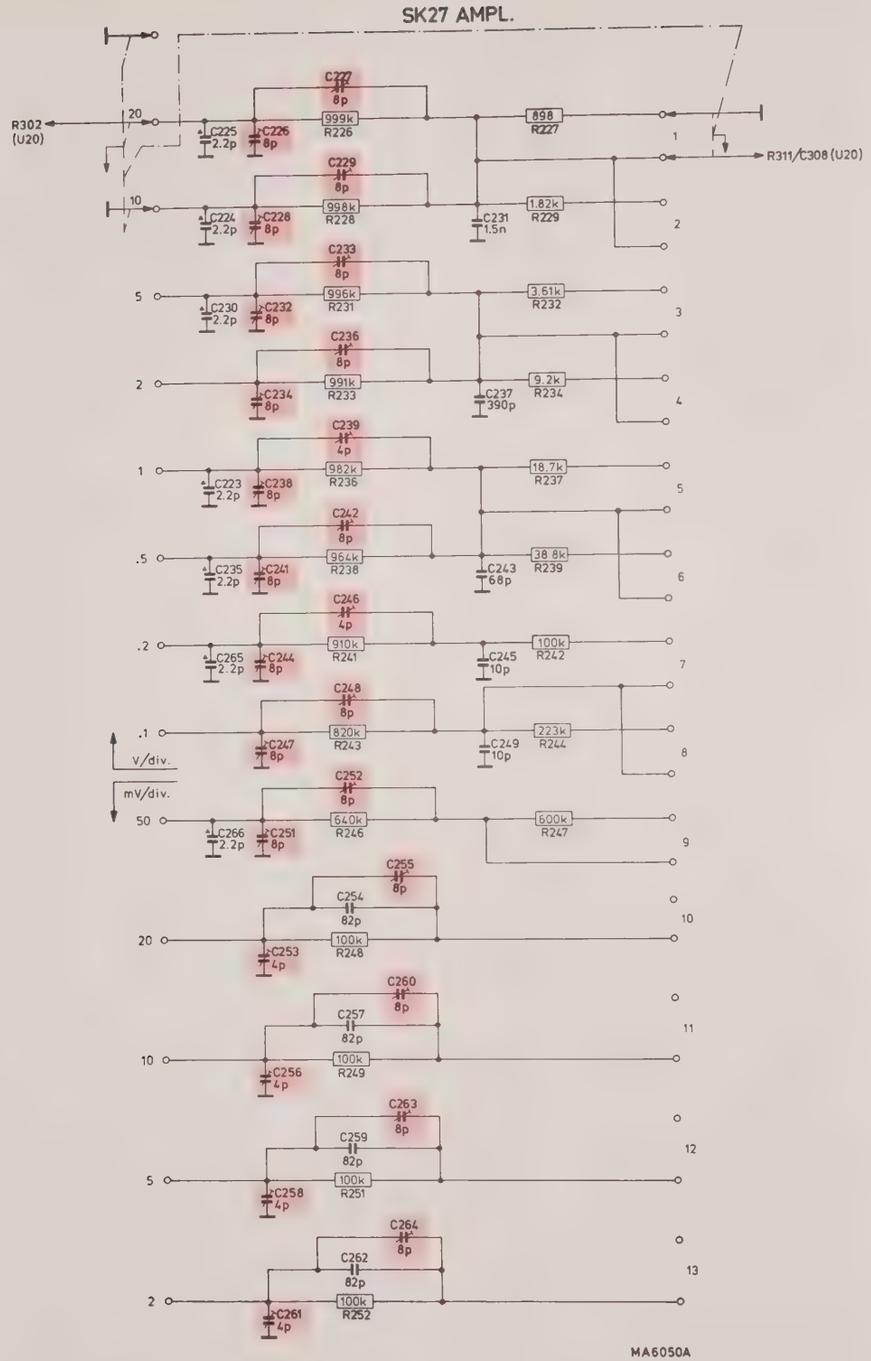


Fig. XIV-2. Circuit diagram

ATTENUATOR B UNIT 22

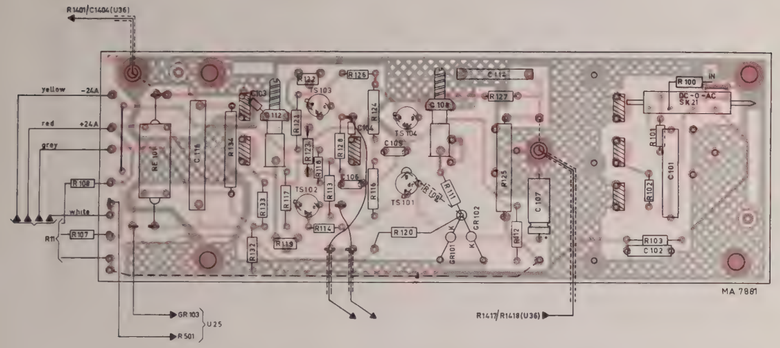


Fig. XIV-3a. Board 1

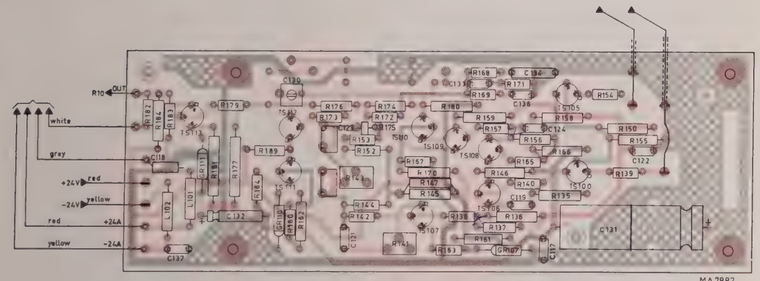


Fig. XIV-3b. Board 2

Component location

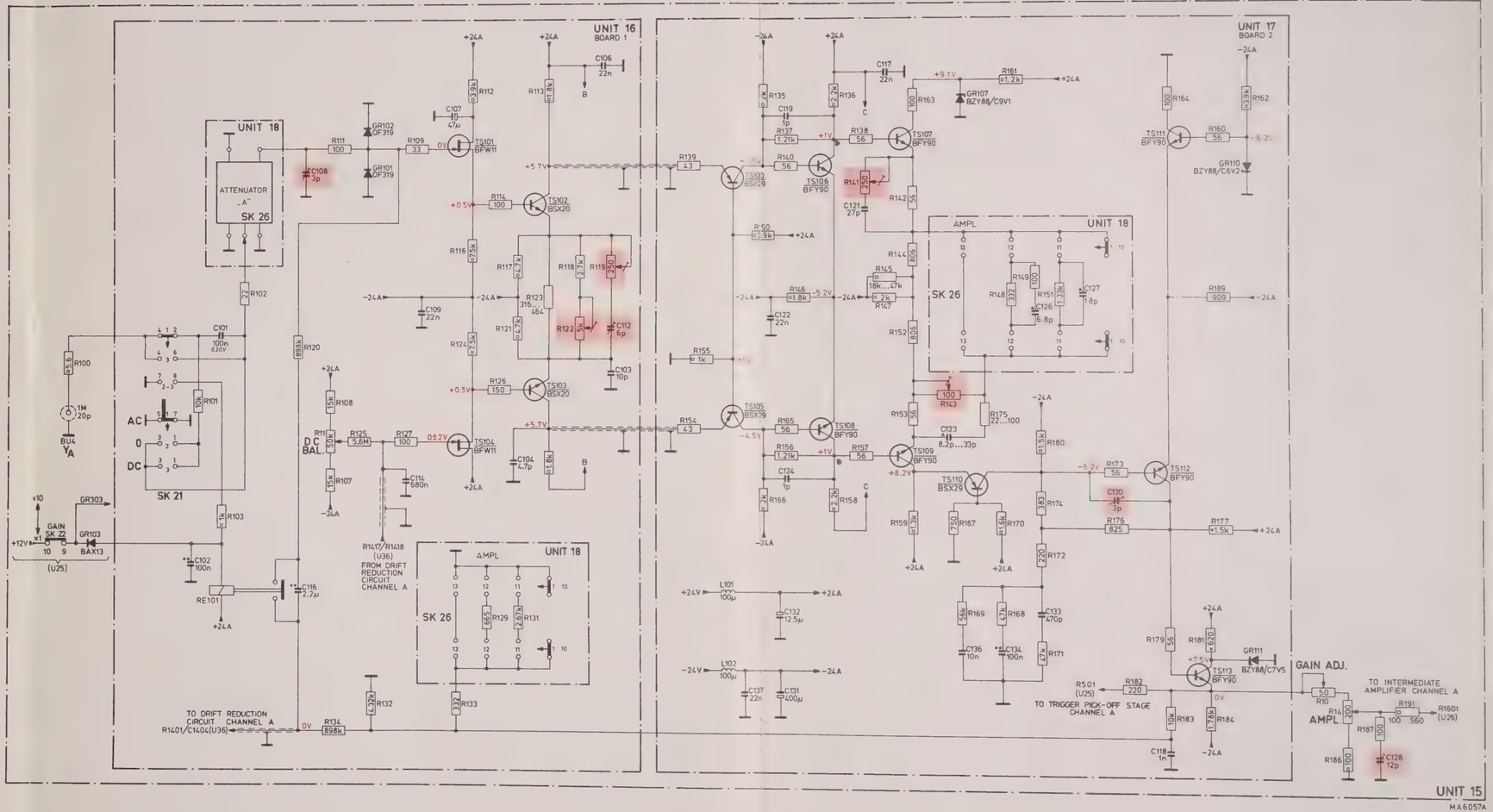


Fig. XIV-3. Circuit diagram

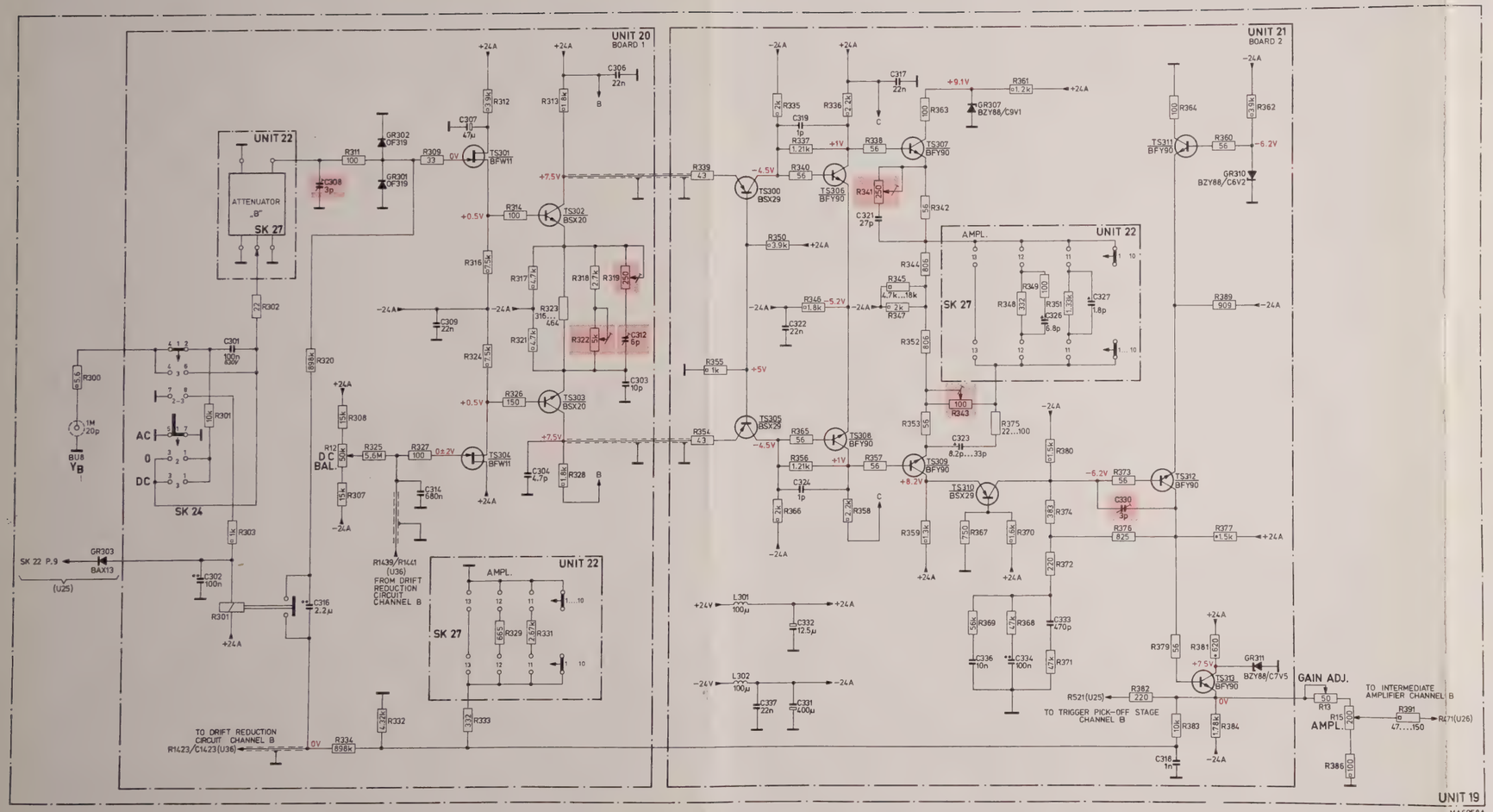


Fig. XIV-4. Circuit diagram

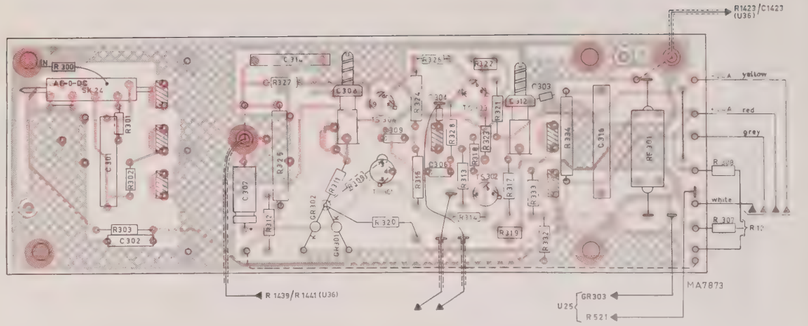


Fig. XIV-4a. Board 1

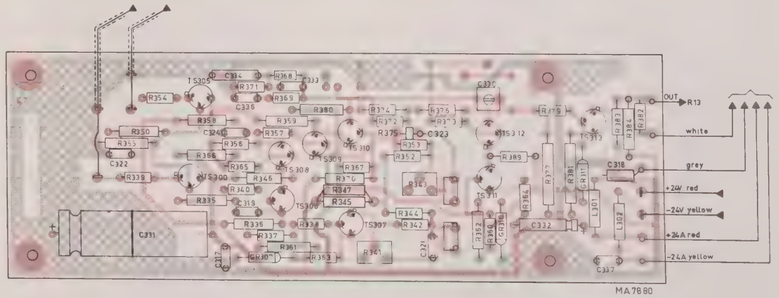


Fig. XIV-4b. Board 2

Component location

PREAMPLIFIER B UNIT 19

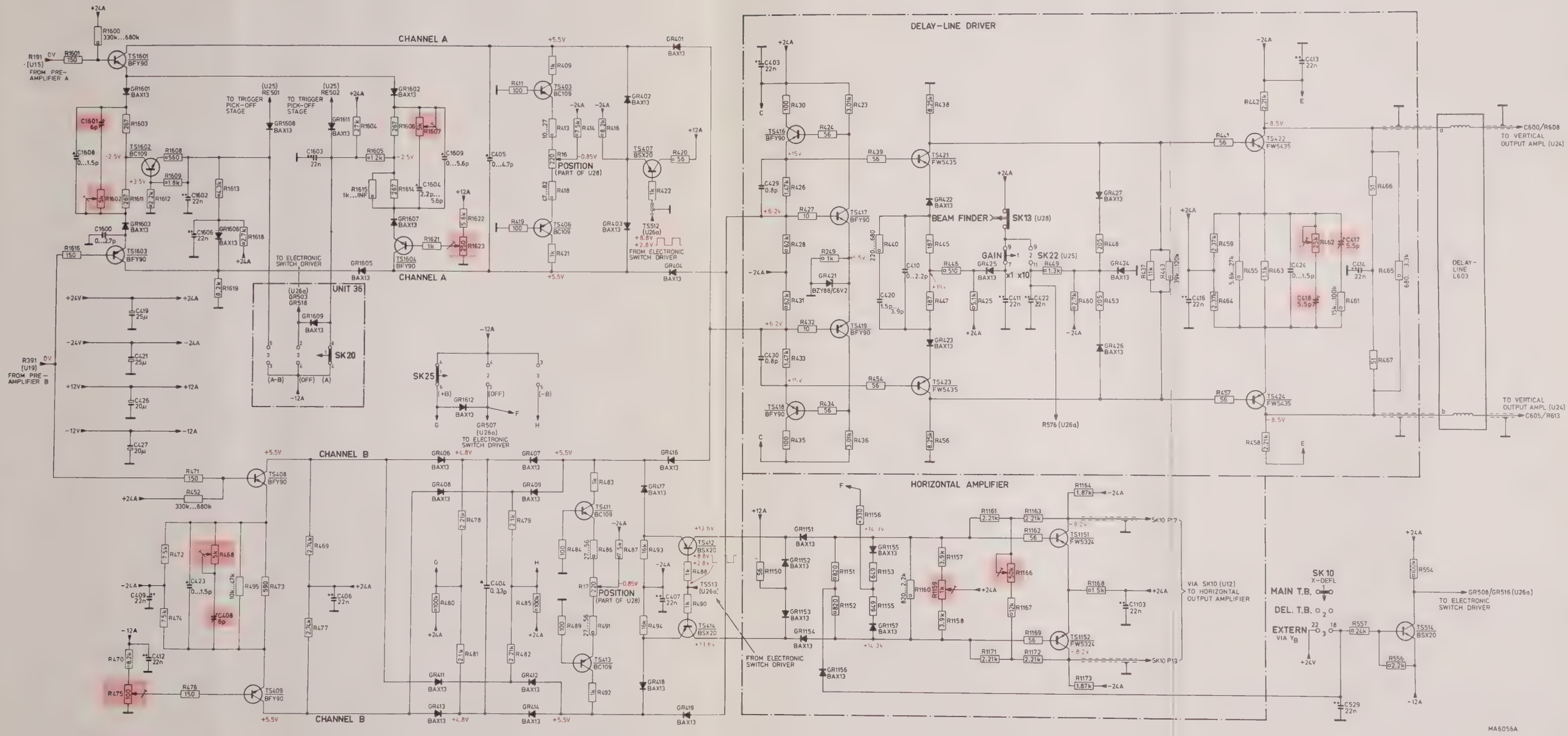


Fig. XIV-5. Circuit diagram

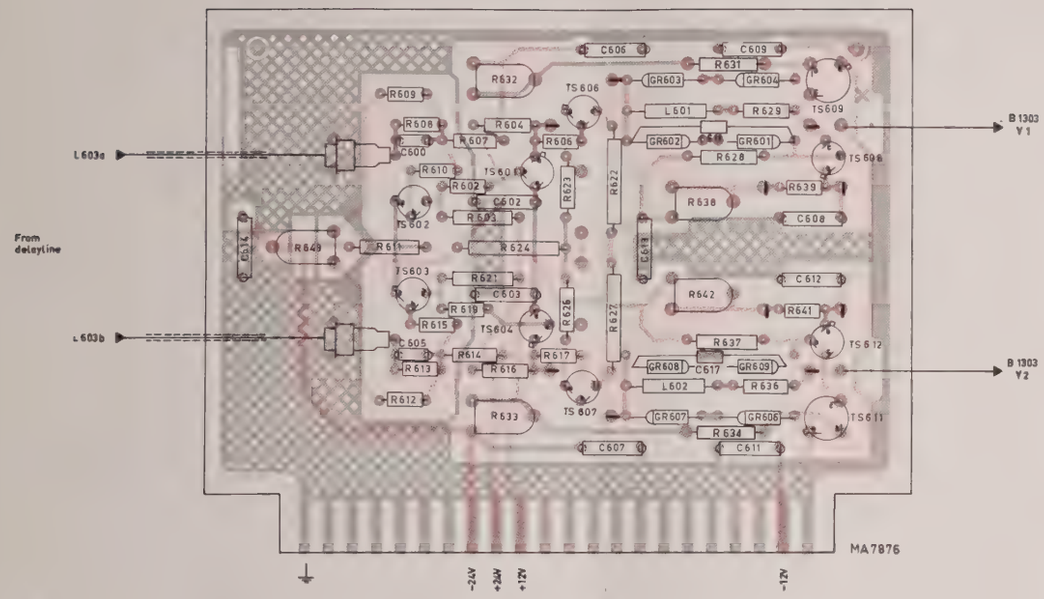


Fig. XIV-6a. Component location

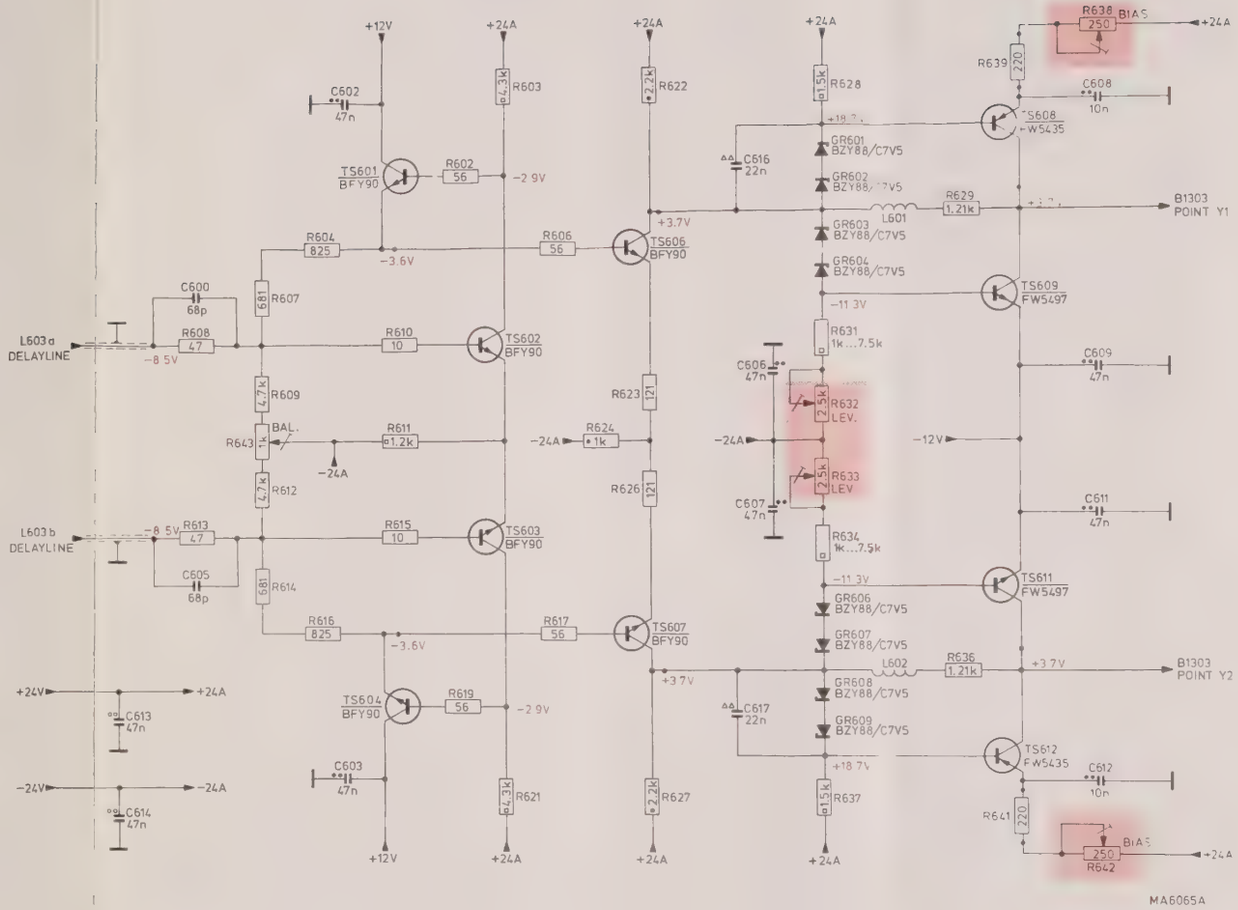


Fig. XIV-6. Circuit diagram

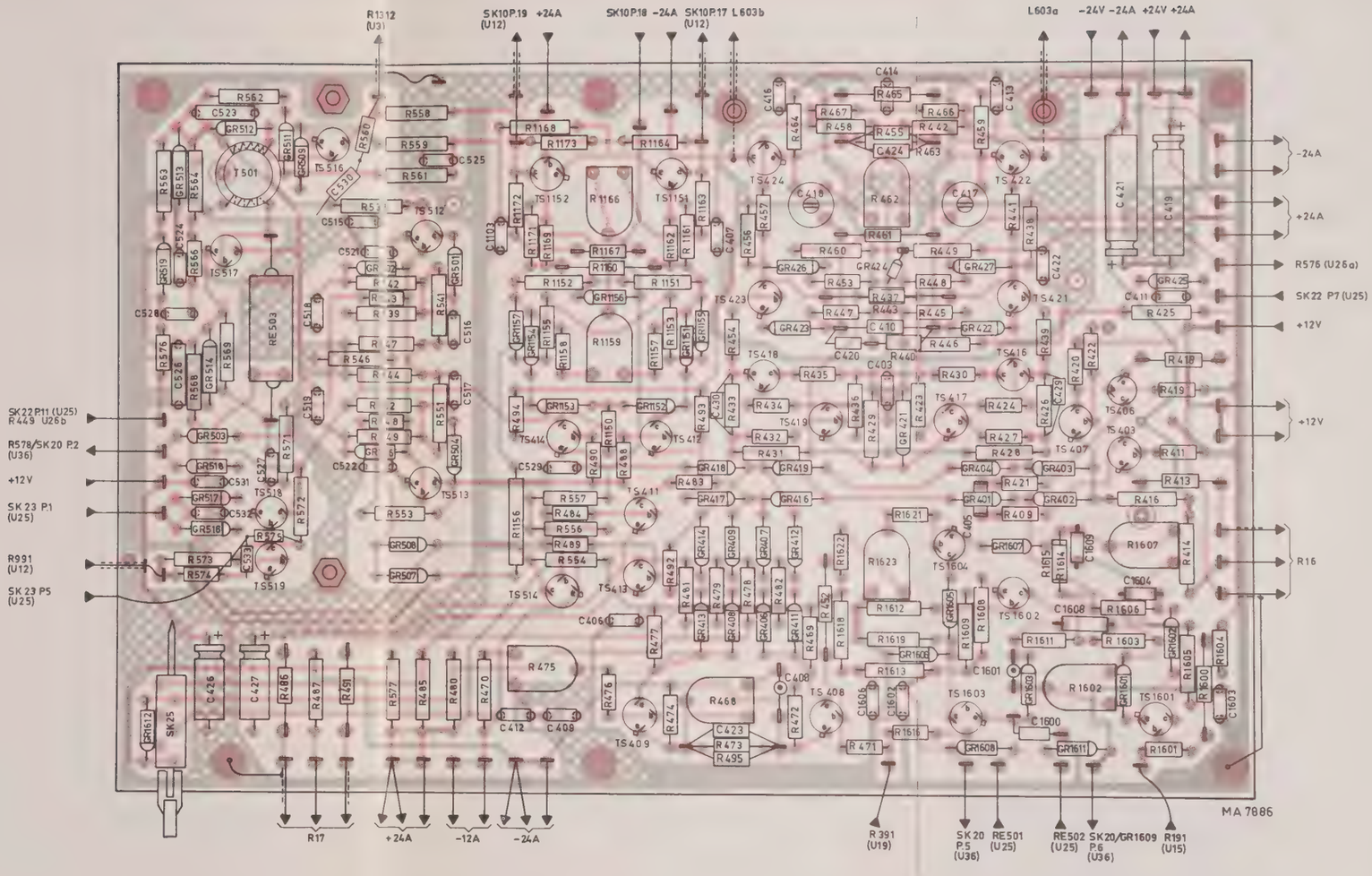


Fig. XIV-7. Component location

ELECTRONIC SWITCH DRIVER AND INTERMEDIATE AMPLIFIER UNIT 26a, b

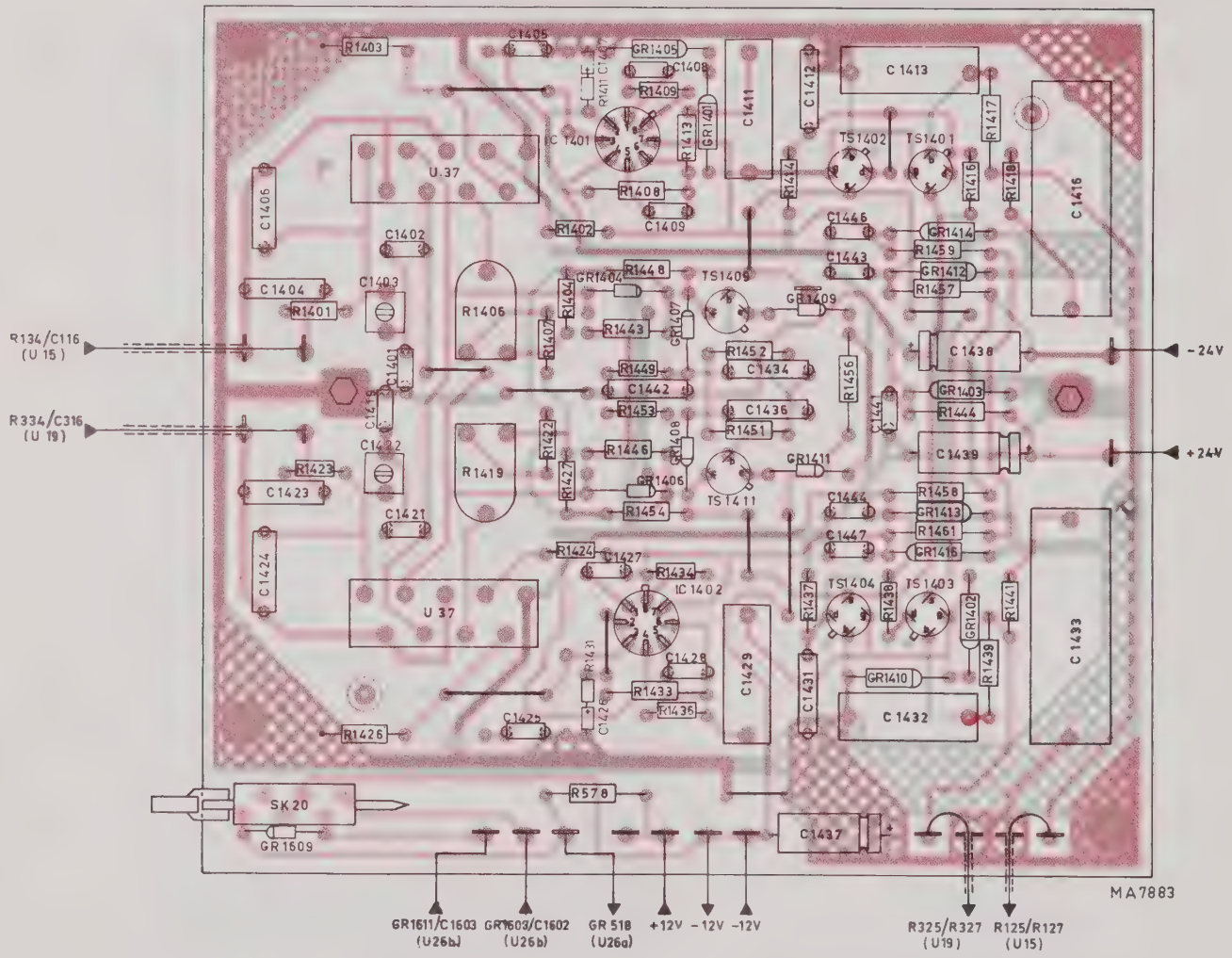


Fig. XIV-8a. Component location

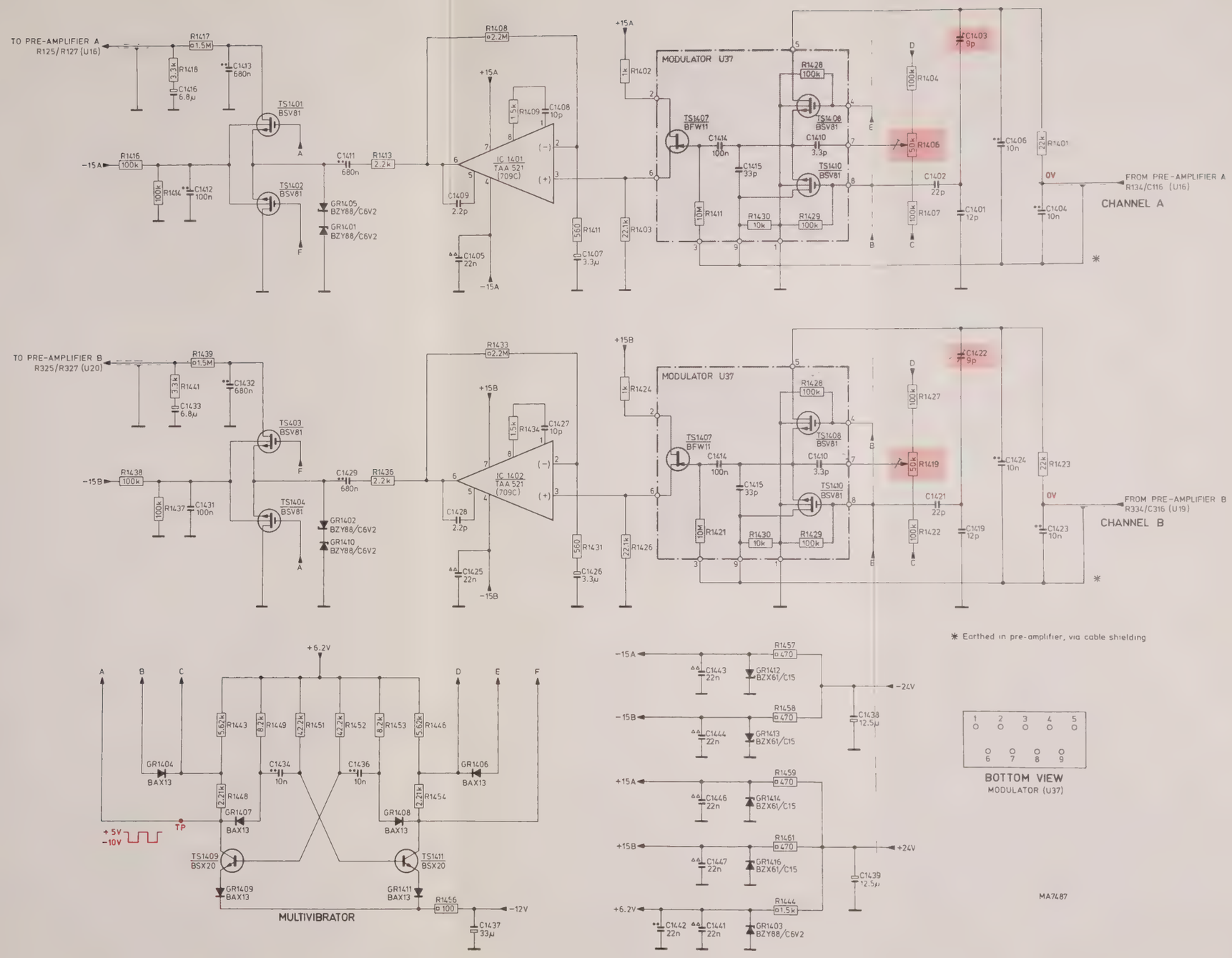


Fig. XIV-8. Circuit diagram

DRIFT REDUCTION AMPLIFIER UNIT 26c

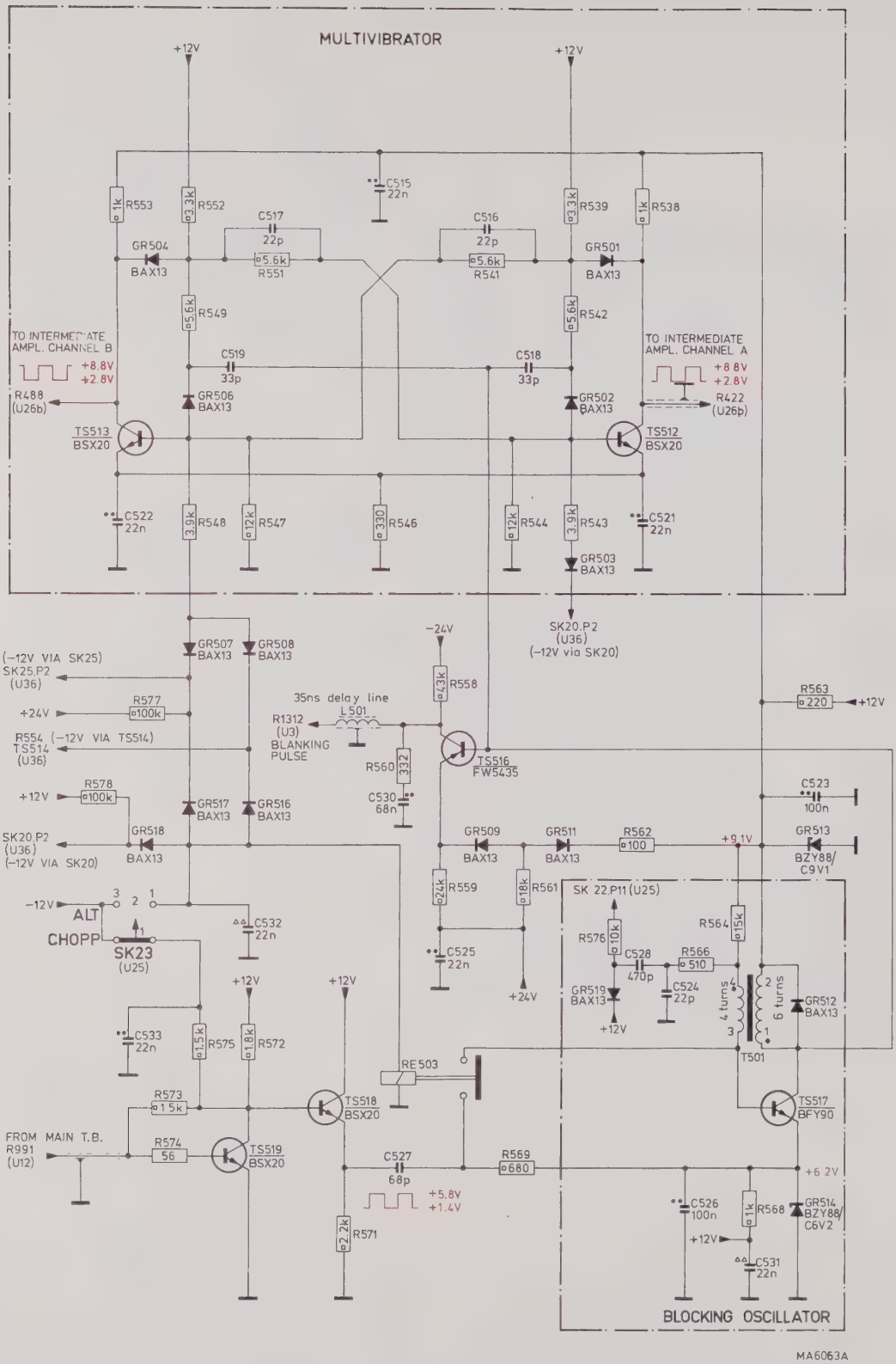


Fig. XIV-9. Circuit diagram

(for component location see Fig. XIV-7)

ELECTRONIC SWITCH DRIVER UNIT U26a

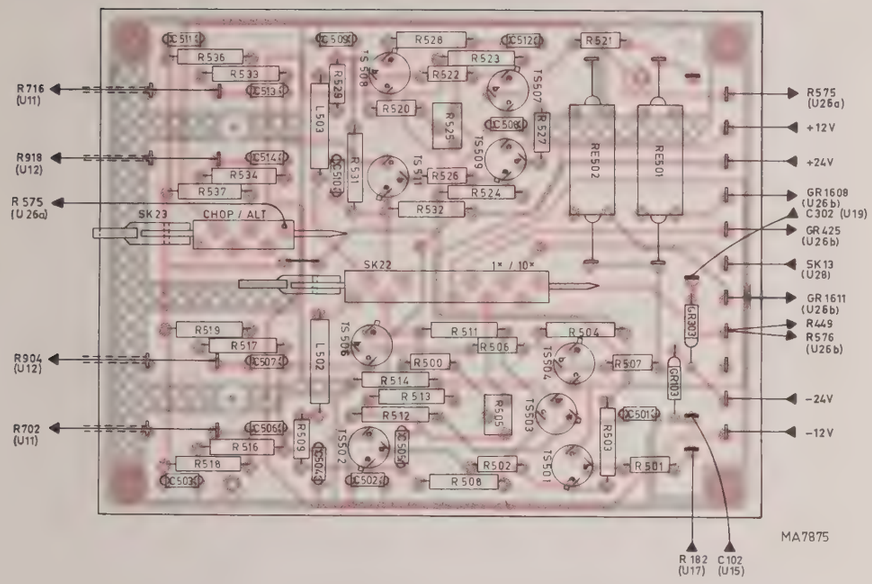


Fig. XIV-10a. Component location

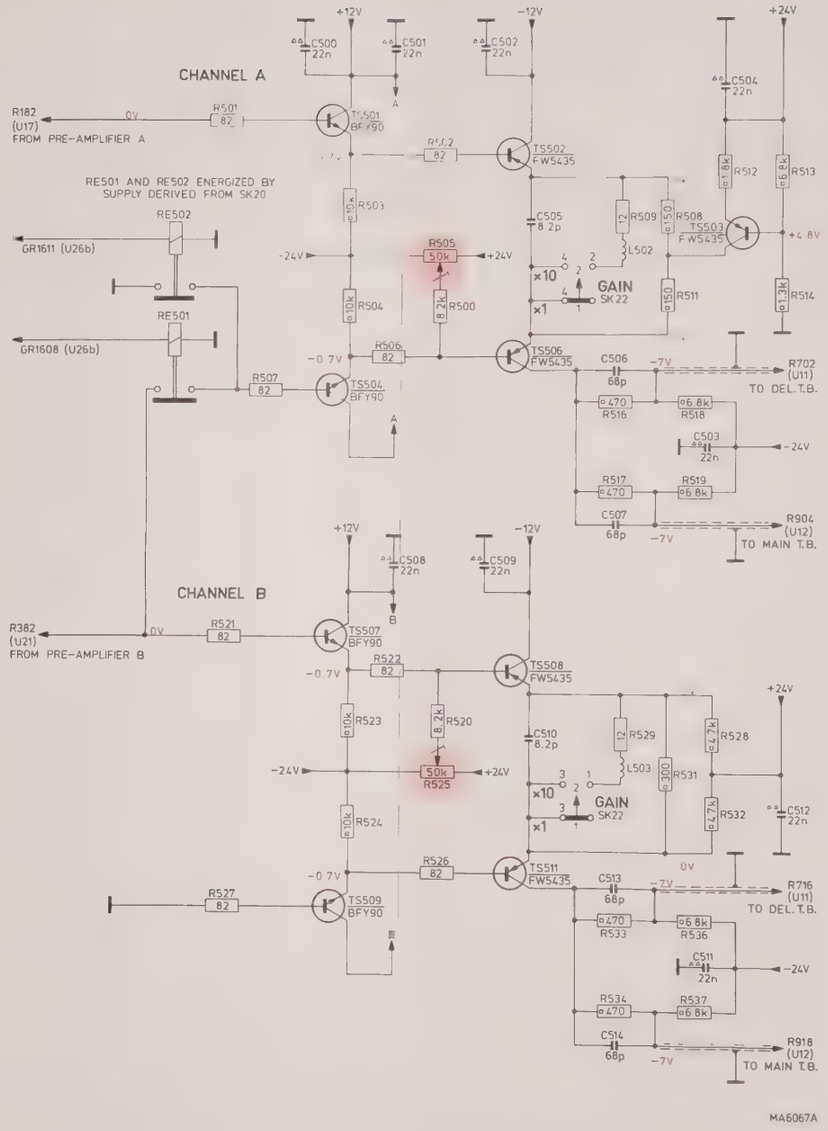


Fig. XIV-10. Circuit diagram

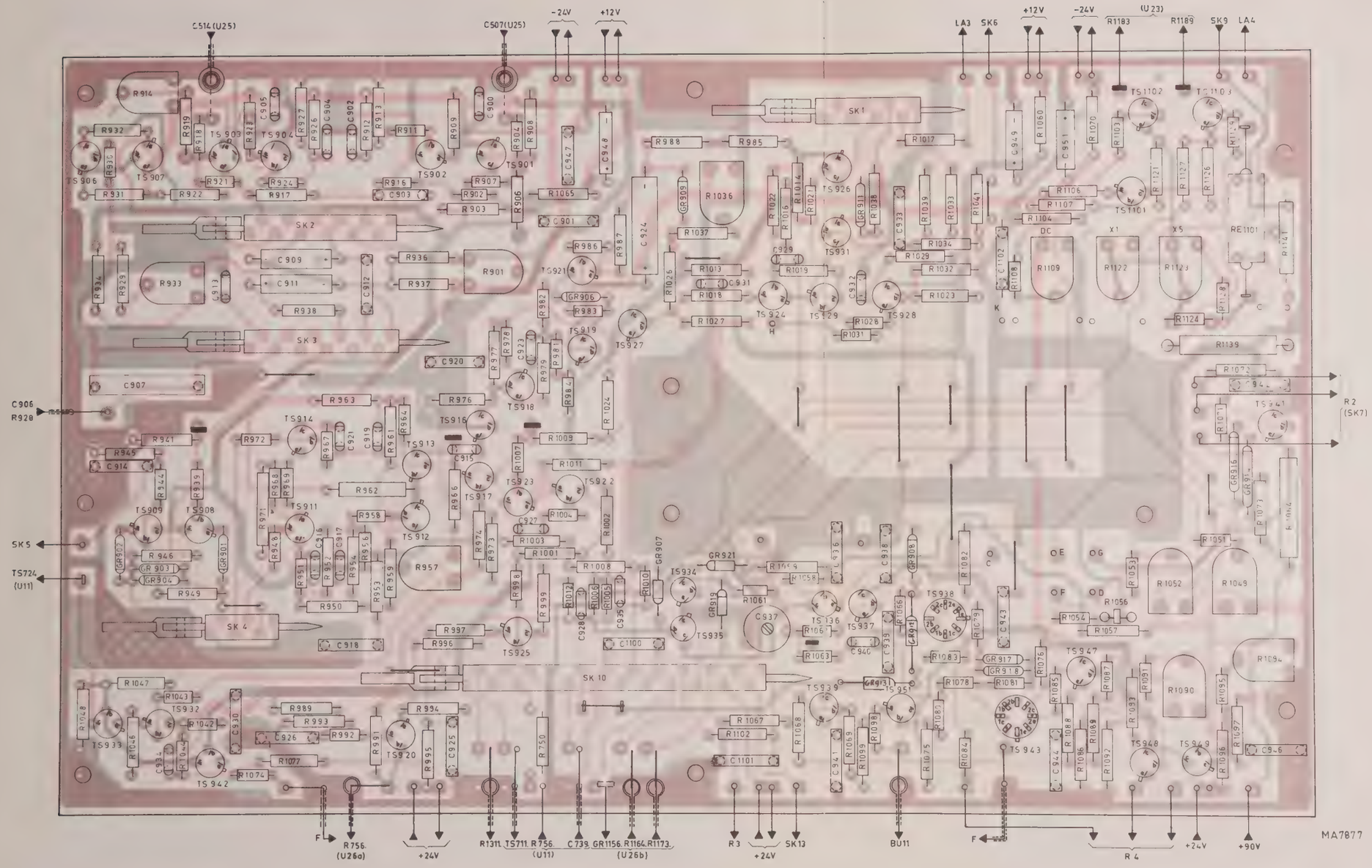


Fig. XIV-11b. Component location

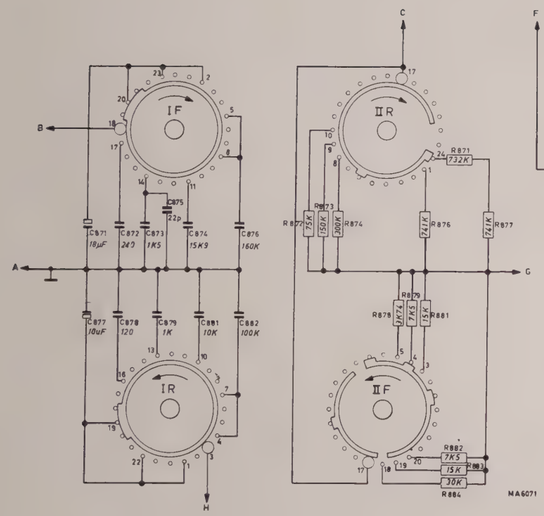
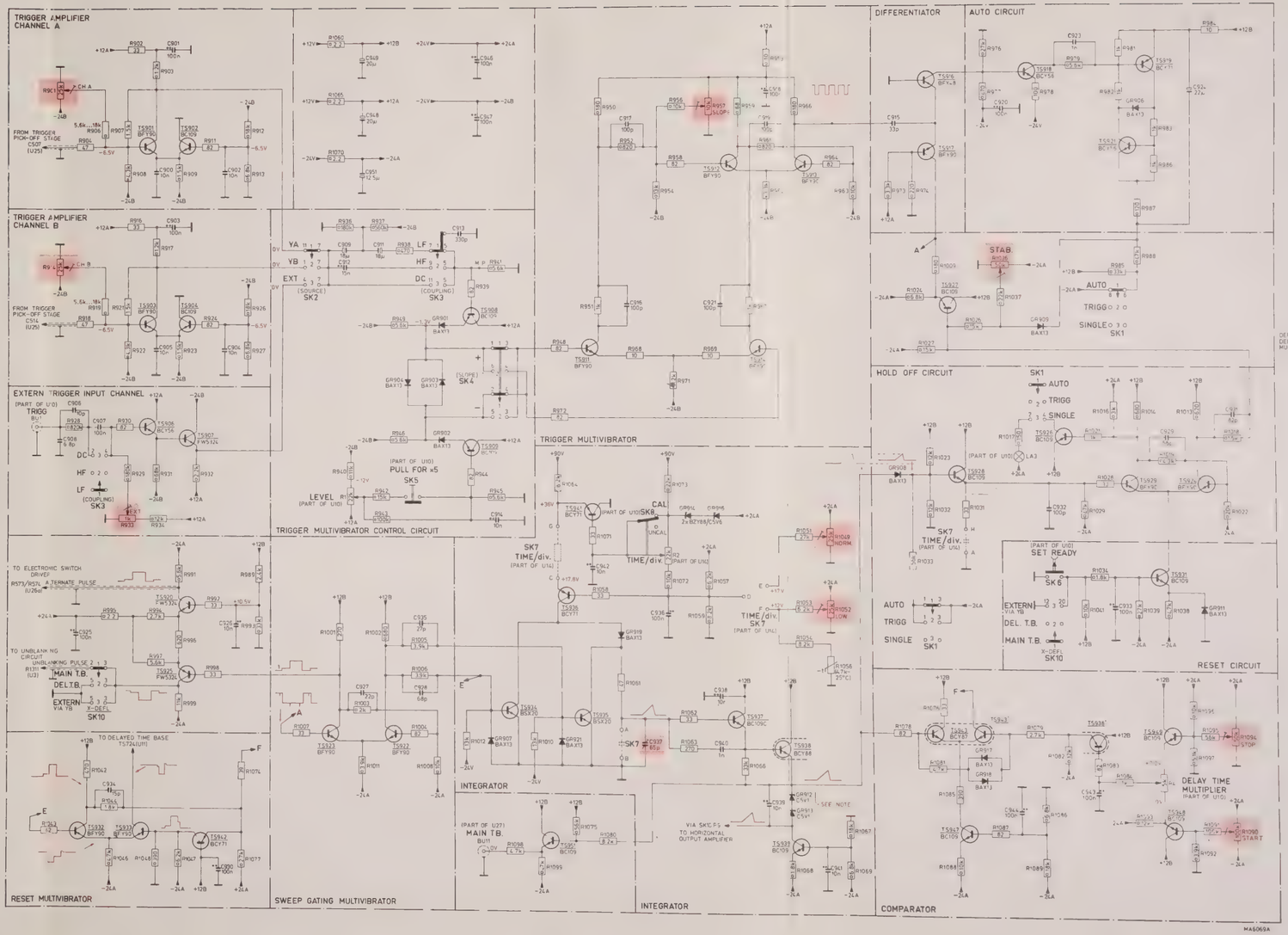


Fig. XIV-11a. TIME/div. switch SK7



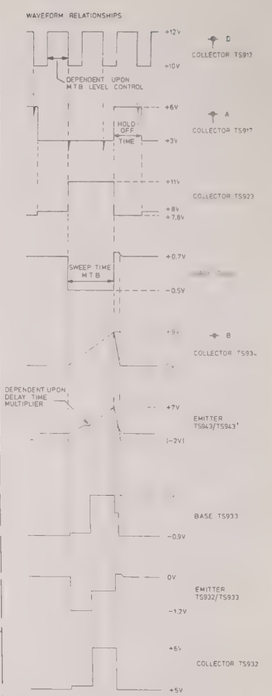


Fig. XIV-11. Circuit diagram

MAIN TIME BASE UNIT 12

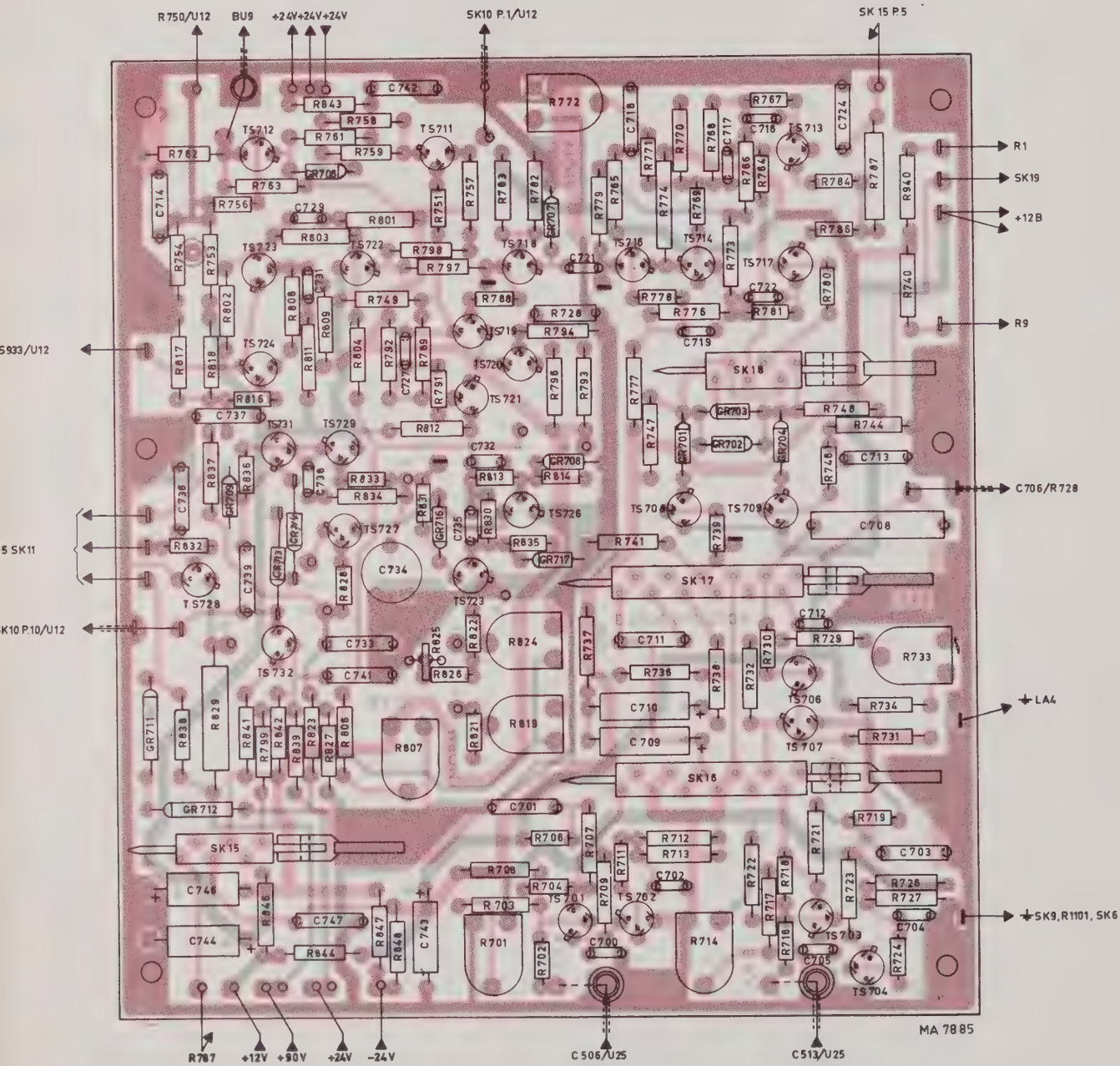


Fig. XIV-12b. Component location

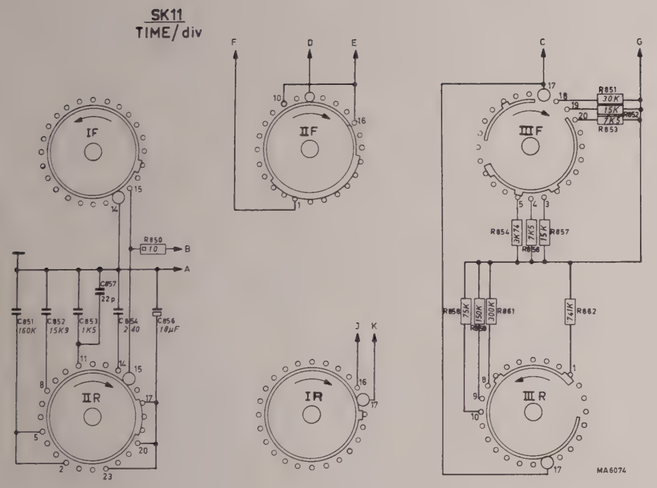
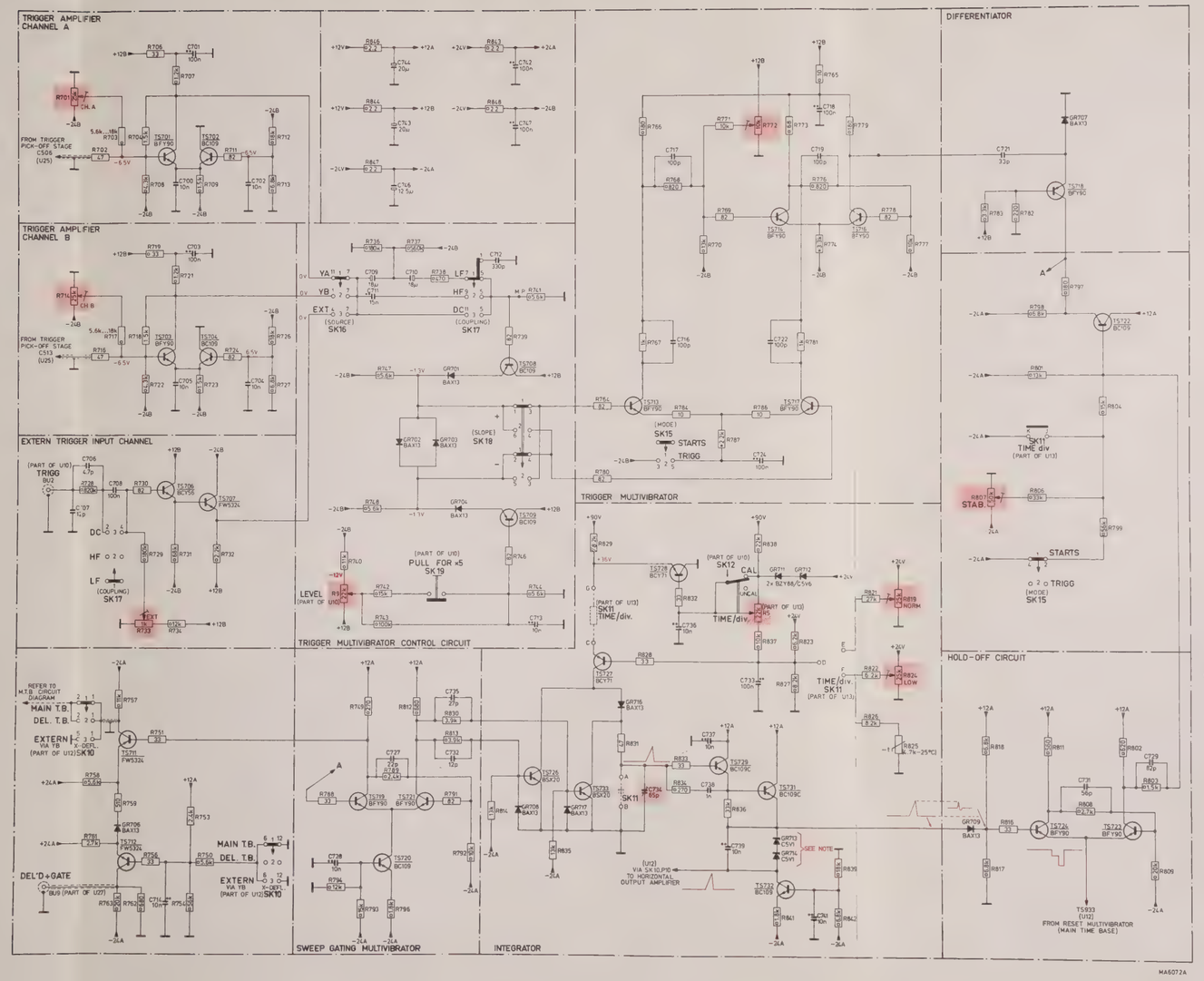


Fig. XIV-12a. TIME/div. switch SK11



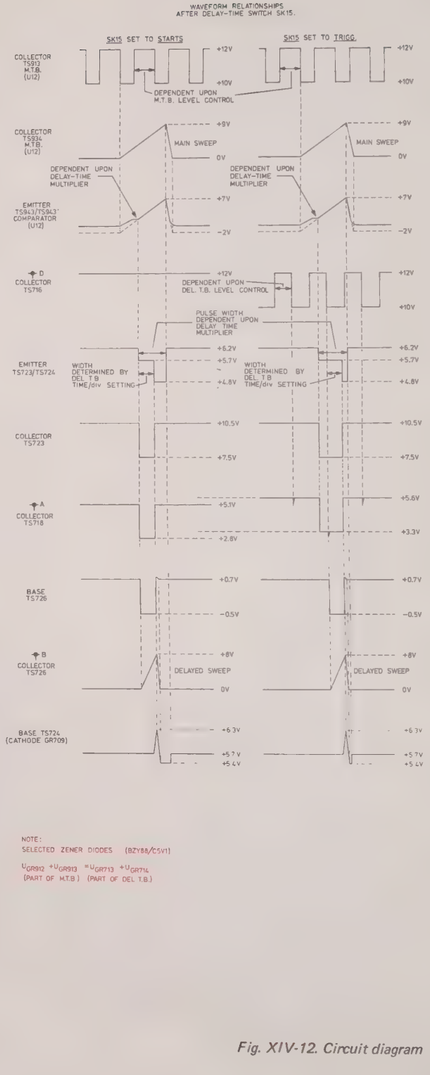


Fig. XIV-12. Circuit diagram

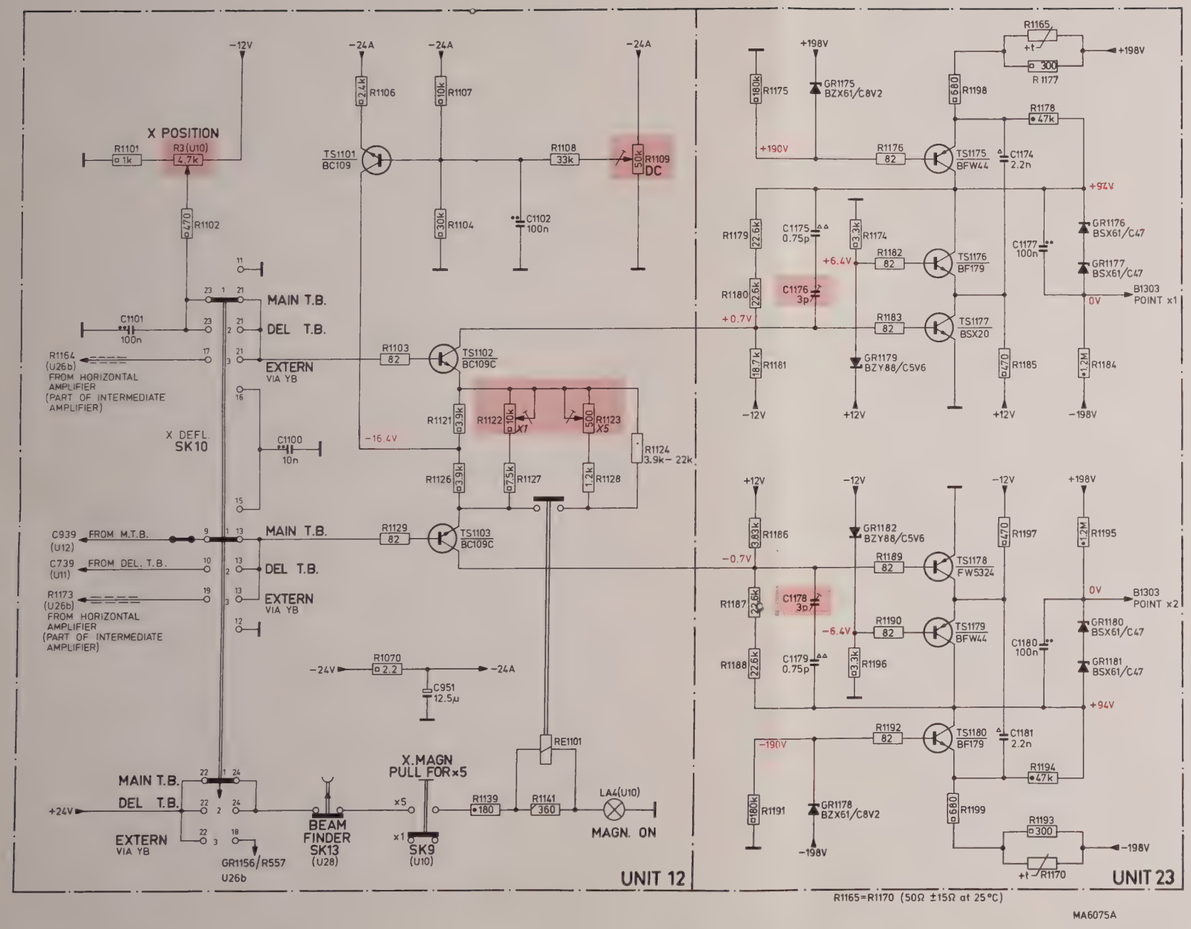


Fig. XIV-13. Circuit diagram

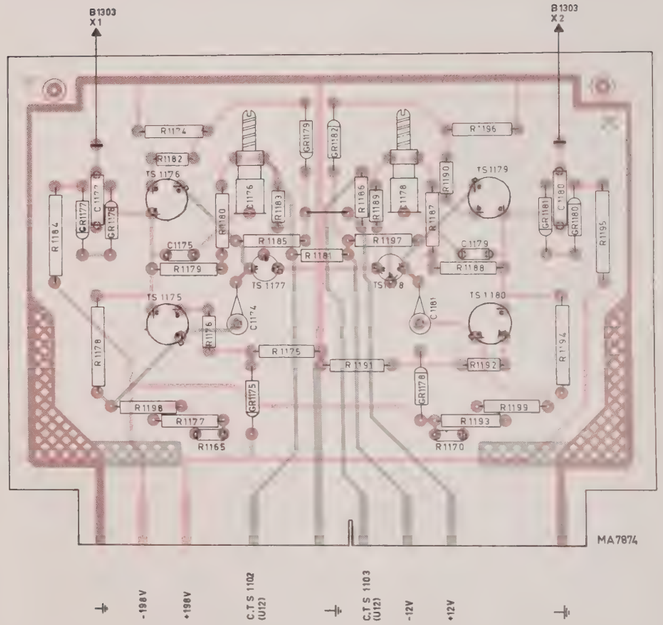


Fig. XIV-13a. Component location

HORIZONTAL OUTPUT AMPLIFIER UNIT 23

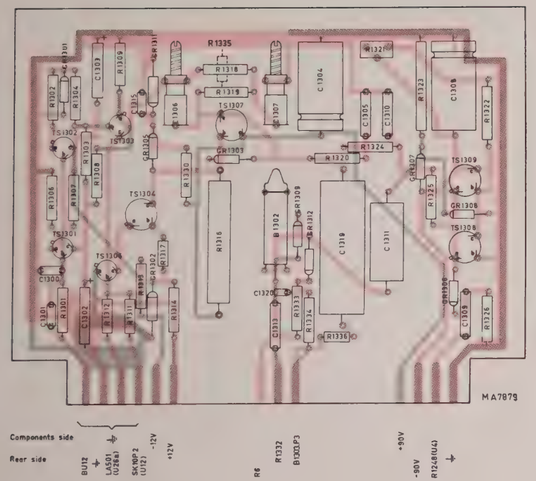
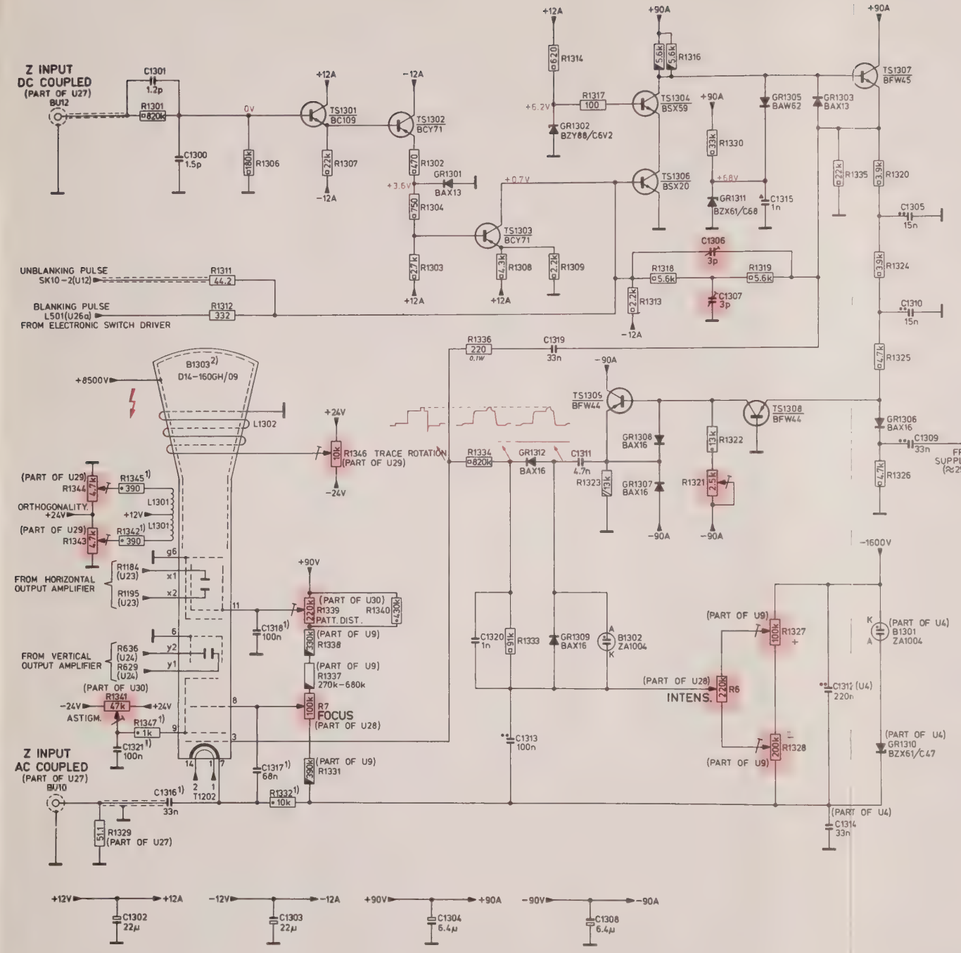


Fig. XIV-14a. Component location



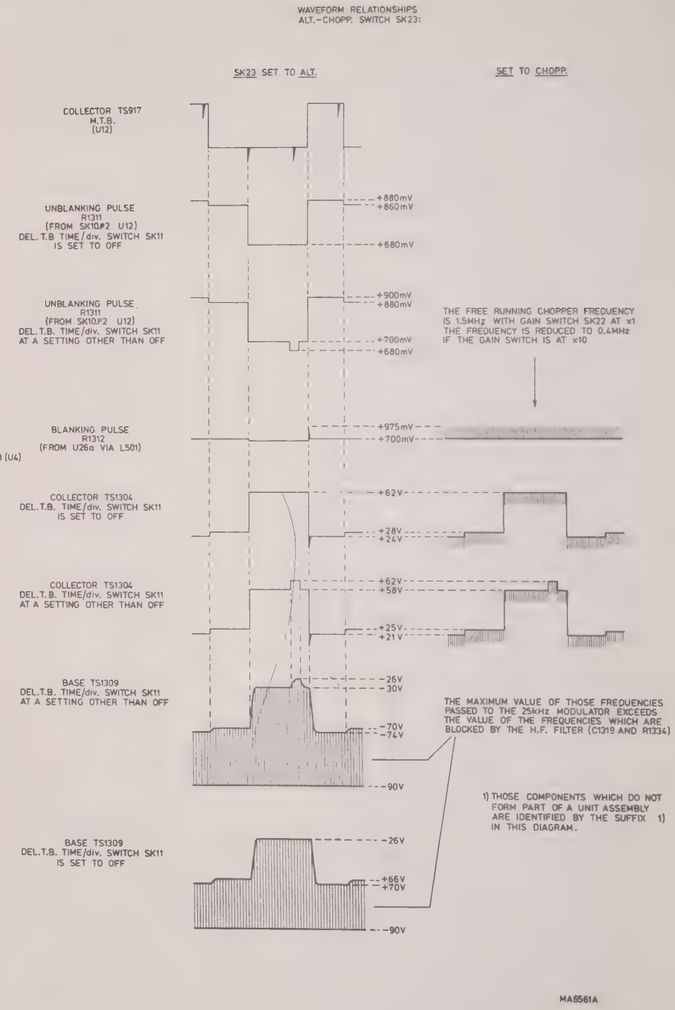

WAVEFORM RELATIONSHIPS ALT.-CHOPP. SWITCH SK23:
SK23 SET TO ALT.
SET TO CHOPP.
COLLECTOR TS917 M.T.B. (U12)
UNBLANKING PULSE R1311 (FROM SK10P2 U12) DEL.T.B TIME/div. SWITCH SK11 IS SET TO OFF
UNBLANKING PULSE R1311 (FROM SK10P2 U12) DEL.T.B. TIME/div. SWITCH SK11 AT A SETTING OTHER THAN OFF
BLANKING PULSE R1312 (FROM U26a VIA L501)
COLLECTOR TS1304 DEL.T.B. TIME/div. SWITCH SK11 IS SET TO OFF
COLLECTOR TS1304 DEL.T.B. TIME/div. SWITCH SK11 AT A SETTING OTHER THAN OFF
BASE TS1309 DEL.T.B. TIME/div. SWITCH SK11 AT A SETTING OTHER THAN OFF
BASE TS1309 DEL.T.B. TIME/div. SWITCH SK11 IS SET TO OFF
THE FREE RUNNING CHOPPER FREQUENCY IS 1.5MHz WITH GAIN SWITCH SK22 AT x1 THE FREQUENCY IS REDUCED TO 0.4MHz IF THE GAIN SWITCH IS AT x10
THE MAXIMUM VALUE OF THOSE FREQUENCIES PASSED TO THE 25kHz MODULATOR EXCEEDS THE VALUE OF THE FREQUENCIES WHICH ARE BLOCKED BY THE H.F. FILTER (C1319 AND R1334)
1) THOSE COMPONENTS WHICH DO NOT FORM PART OF A UNIT ASSEMBLY ARE IDENTIFIED BY THE SUFFIX 1) IN THIS DIAGRAM.
MA6561A

Fig. XIV-14. Circuit diagram

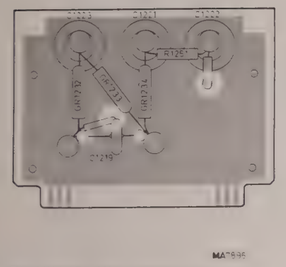


Fig. XIV-15a. High tension unit

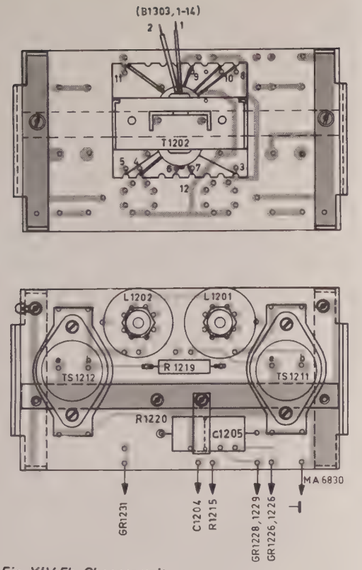


Fig. XIV-5b. Chopper unit

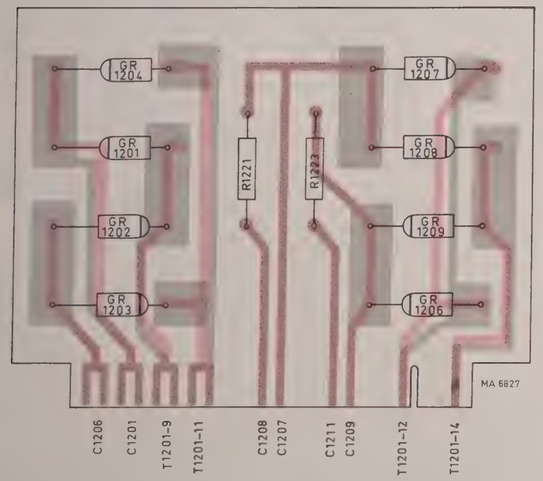


Fig. XIV-15c. Diode panel

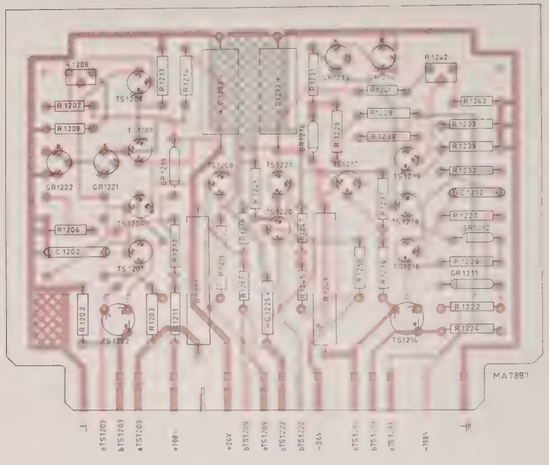


Fig. XIV-15d. Supply panel

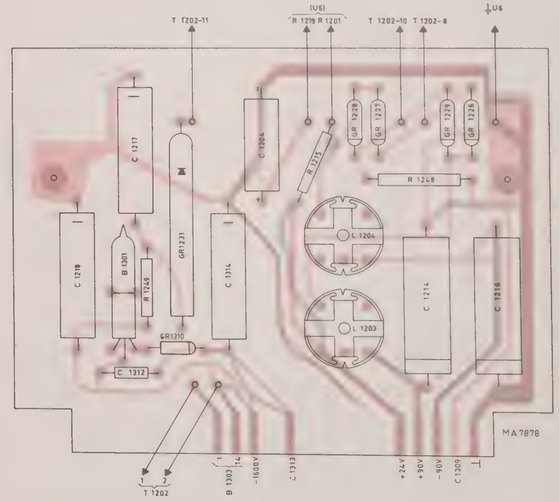


Fig. XIV-15e. Chopper panel

component location

POWER SUPPLY

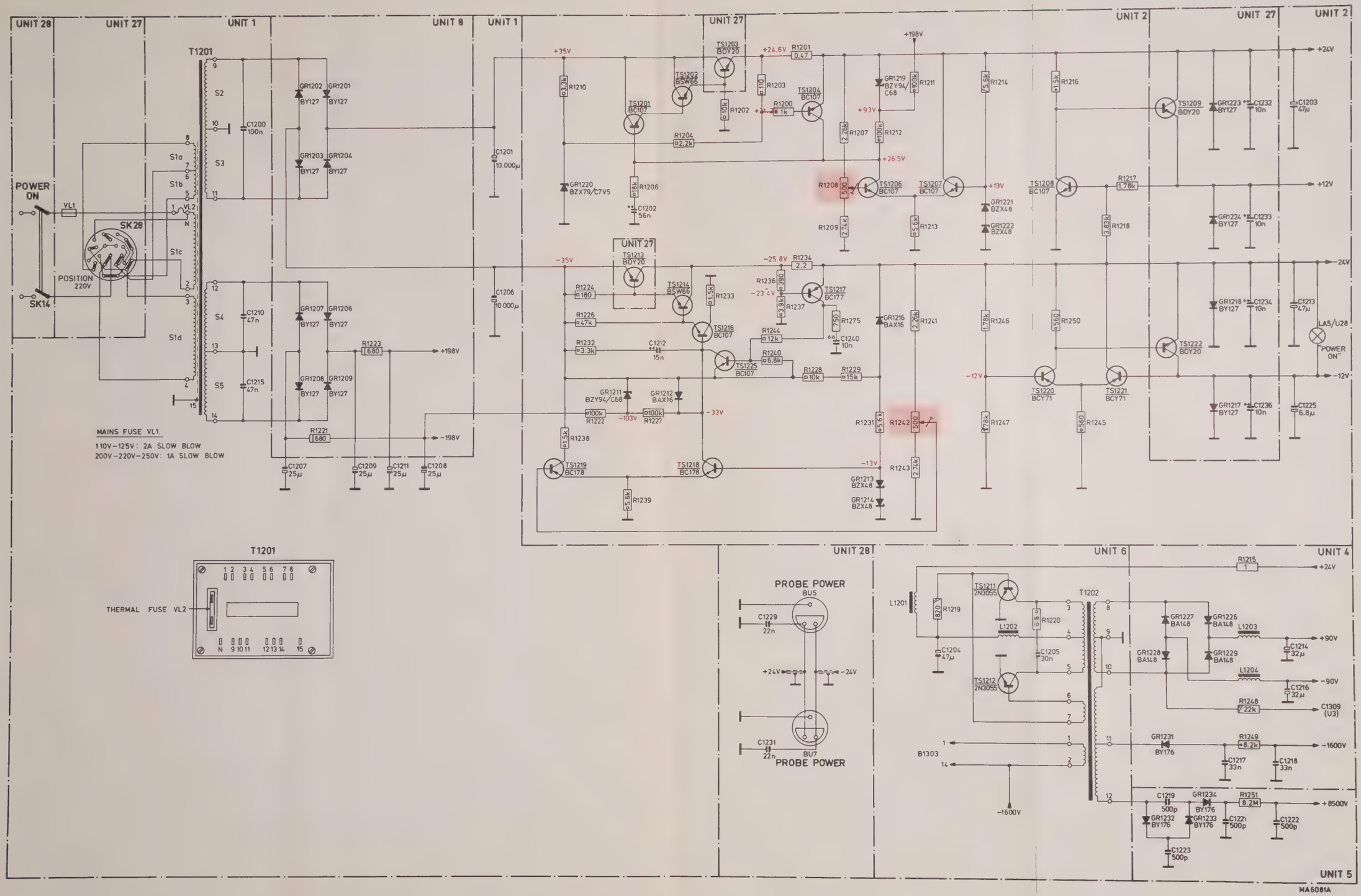


Fig. XIV-15. Circuit diagram

POWER SUPPLY

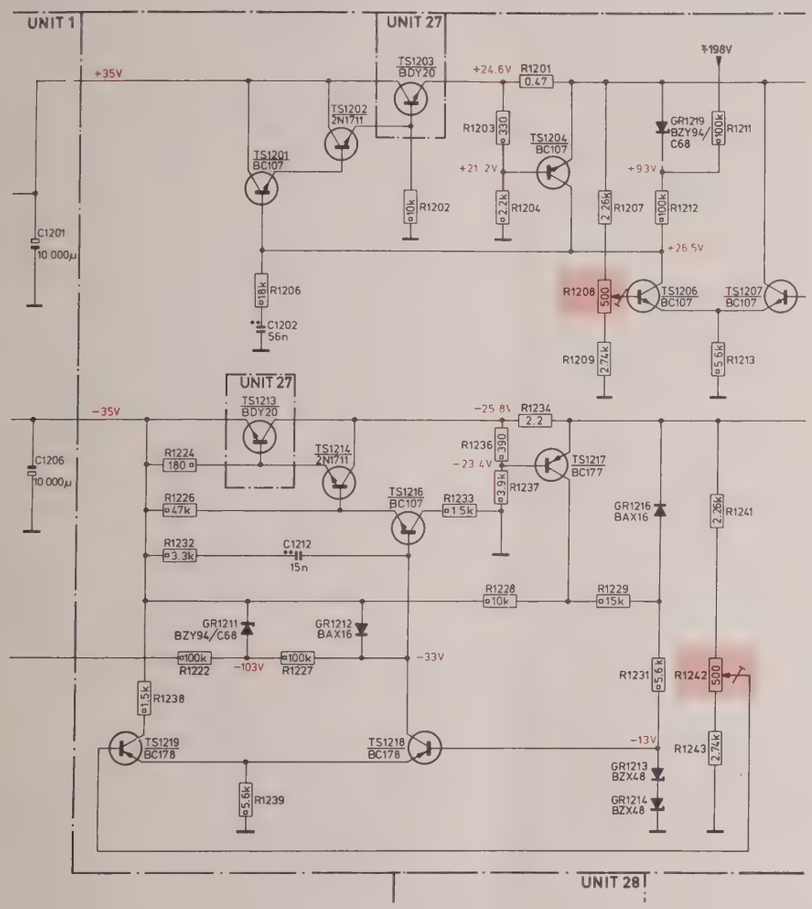


Fig. XIV-16. Detailed circuit diagram

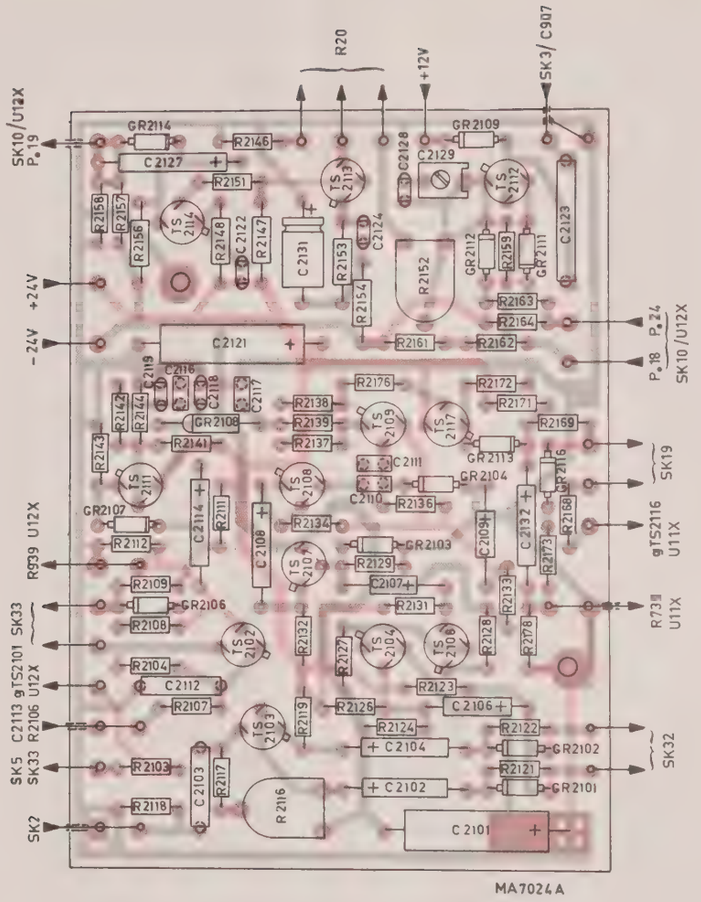


Fig. XIV-17a. Component location

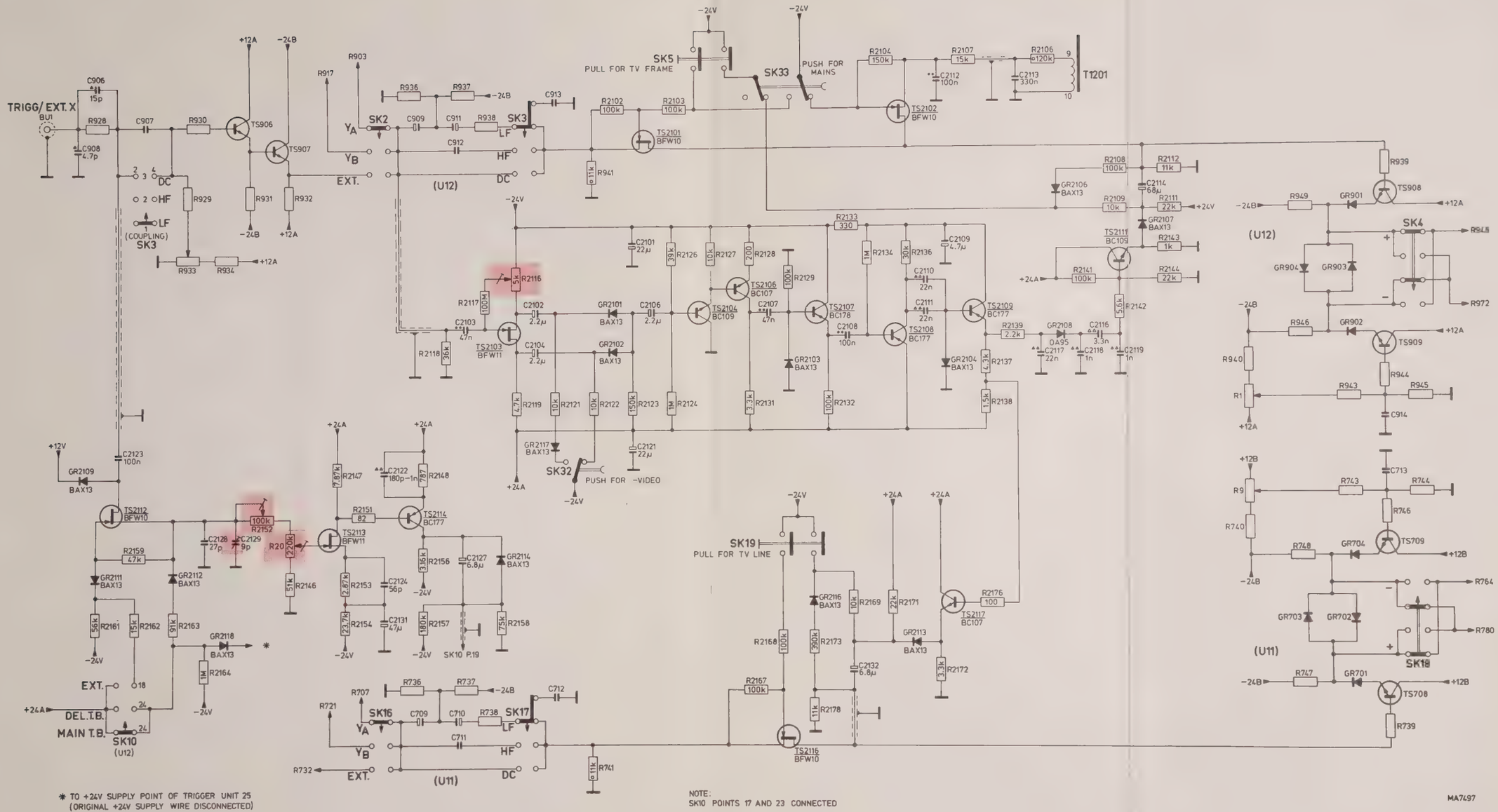


Fig. XIV-17. Circuit diagram
(with PM 3250 circuit modifications)

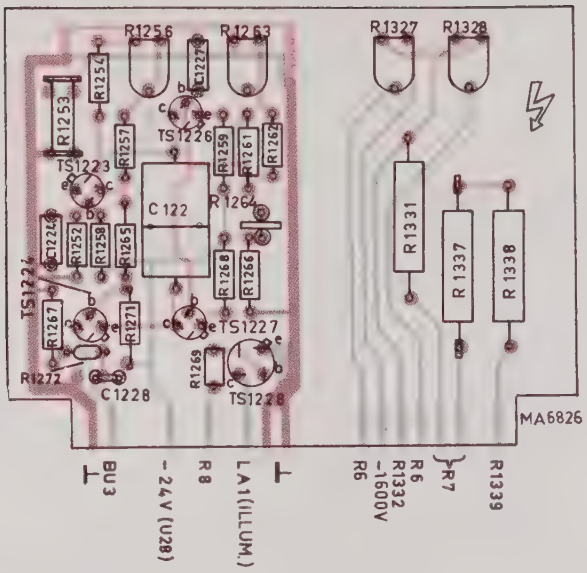


Fig. XIV-18a. Components location

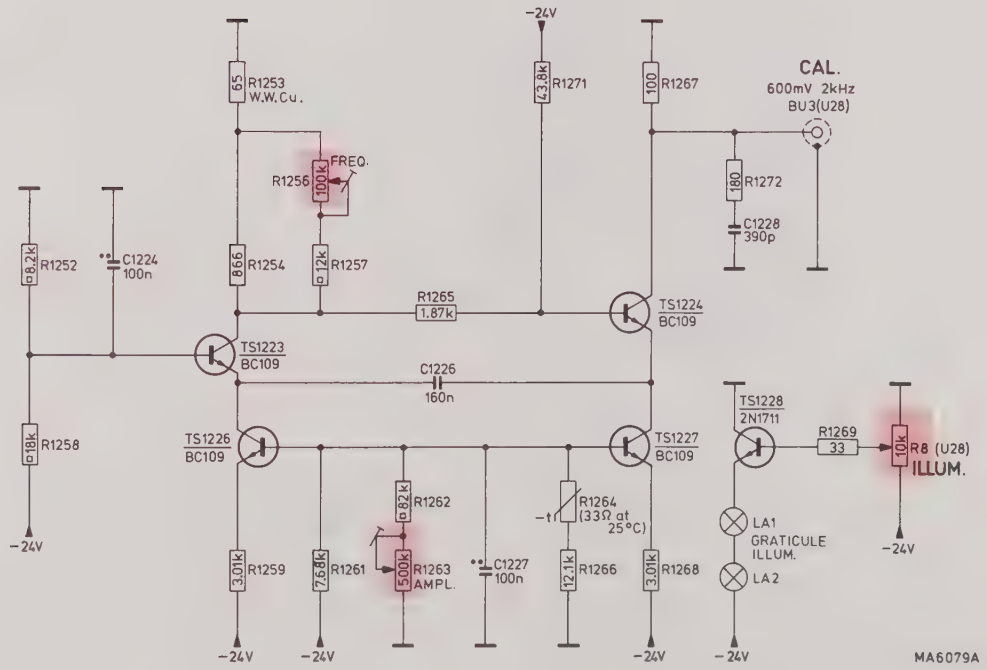
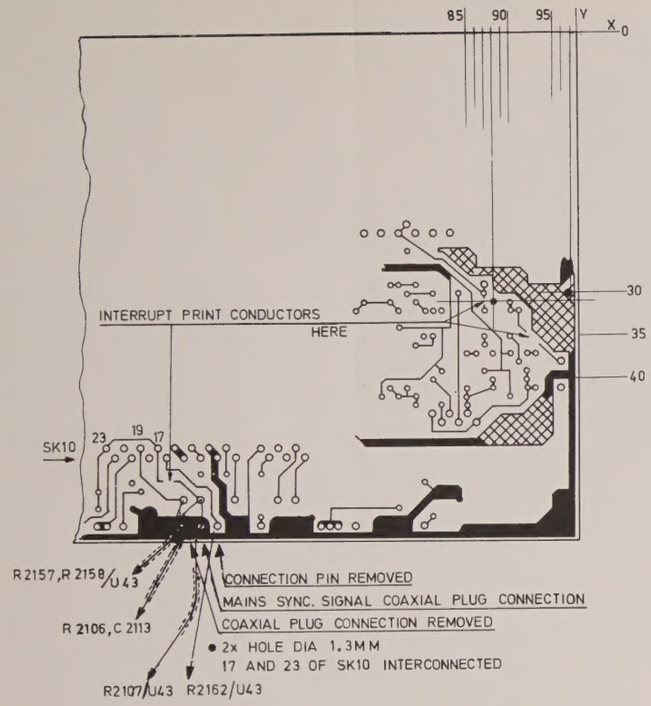
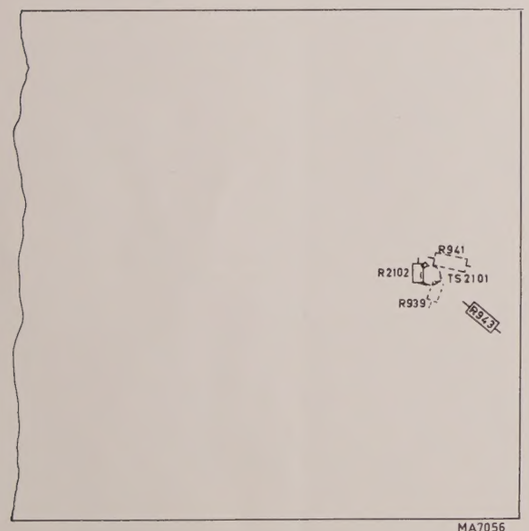


Fig. XIV-18. Circuit diagram

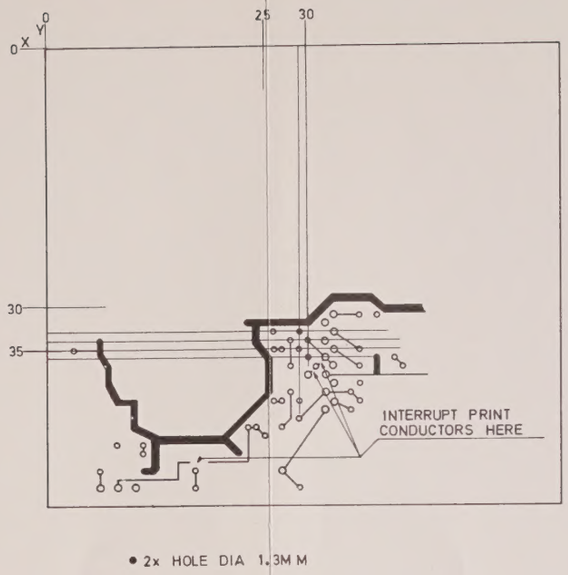


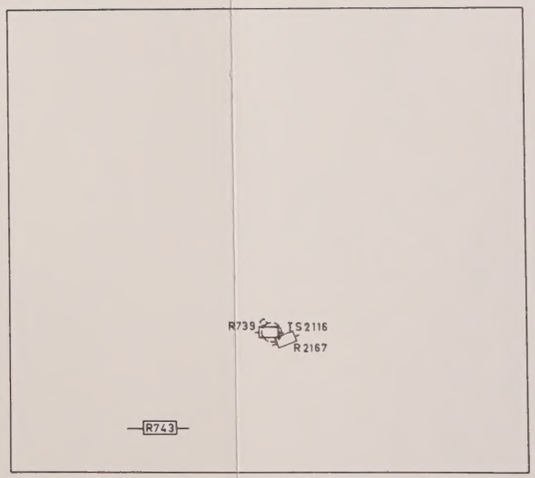


R 941 AND R939 DISPLACED (MOUNTED ON COMPONENTS-SIDE OF PRINT)
R943 AND R2102 MOUNTED
TS2101 MOUNTED ON COMPONENTS'-SIDE OF PRINT

Fig. XIV-19. Modification printed circuit board

MAIN TIME BASE UNIT 12, PM 3250X
(Rear side)





R739 DISPLACED
R743 AND R2167 MOUNTED
TS2116 MOUNTED ON COMPONENTS'-SIDE OF PRINT

Fig. XIV-20. Modification printed circuit board

DELAYED TIME BASE UNIT 11, PM 3250X
(Rear side)

QUALITY REPORTING

CODING SYSTEM FOR FAILURE DESCRIPTION

The following information is meant for Philips service workshops only and serves as a guide for exact reporting of service repairs and maintenance routines on the workshop charts.
For full details reference is made to Information G1 (Introduction) and Information Cd 689 (Specific information for Test and Measuring Instruments).

LOCATION

□□□

Unit number
e.g. 000A or 0001 (for unit A or 1; not 00UA or 00U1)

or: Type number of an accessory (only if delivered with the equipment)
e.g. 9051 or 9532 (for PM 9051 or PM 9532)

or: Unknown/Not applicable
0000

CATEGORY

□

0 Unknown, not applicable (fault not present, intermittent or disappeared)
1 Software error
2 Readjustment
3 Electrical repair (wiring, solder joint, etc.)
4 Mechanical repair (polishing, filing, remachining, etc.)
5 Replacement
6 Cleaning and/or lubrication
7 Operator error
8 Missing items (on pre-sale test)
9 Environmental requirements are not met

COMPONENT/SEQUENCE NUMBER

□□□□

Enter the identification as used in the circuit diagram, e.g.:

GR1003	Diode GR1003
TS0023	Transistor TS23
IC0101	Integrated circuit IC101
R0....	Resistor, potentiometer
C0....	Capacitor, variable capacitor
B0....	Tube, valve
LA....	Lamp
VL....	Fuse
SK....	Switch
BU....	Connector, socket, terminal
T0....	Transformer
L0....	Coil
X0....	Crystal
CB....	Circuit block
RE....	Relay
ME....	Meter, indicator
BA....	Battery
TR....	Chopper

Parts not identified in the circuit diagram:

990000	Unknown/Not applicable
990001	Cabinet or rack (text plate, emblem, grip, rail, graticule, etc.)
990002	Knob (incl. dial knob, cap, etc.)
990003	Probe (only if attached to instrument)
990004	Leads and associated plugs
990005	Holder (valve, transistor, fuse, board, etc.)
990006	Complete unit (p.w. board, h.t. unit, etc.)
990007	Accessory (only those without type number)
990008	Documentation (manual, supplement, etc.)
990009	Foreign object
990099	Miscellaneous

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